TIMKEN

Aerospace Design Guide

for Precision Metric Ball and Cylindrical Roller Bearings

INDEX

The world turns to Timken for innovation to move ahead of the competition. Our contributions to advancing work and living standards – through innovations surrounding friction management and power transmission – are invaluable. We have played a role in virtually all major technologies that have shaped our age, from automobile travel to artificial hearts. You'll find our products wherever you turn – on land, on sea and in space.

When customers turn to us, they are turning to a worldwide team. Because of our ability to help their products perform better, customers honor us with numerous awards each year.

Whether it is a wheel assembly for a family vehicle, bearings for a roller coaster or repair services for rail bearings, we supply the products and services that help keep the world turning.

FRICTION MANAGEMENT SOLUTIONS – A TOTAL SYSTEMS APPROACH

As needs change and advanced motion control systems evolve, Timken leverages its knowledge of friction management to offer a broad range of bearings, related products and integrated services to the marketplace. We supply quality products and services that extend beyond bearings to help all systems run smoothly.

We are committed to providing a wide array of friction management solutions. Customers can benefit by having Timken, a trusted name for more than 100 years, evaluate entire systems, not just individual components. This approach provides cost-effective solutions, while also helping customers to achieve specific objectives.

TECHNOLOGY THAT MOVES YOU

Today, major industries turn to Timken for our ability to influence the fundamentals of motion through the creation, transfer and control of power. We invest in people, attracting scholars, engineers and specialists from around the world. We invest in tools – computers, manufacturing equipment and state-of-the-art laboratories. We invest in the future by identifying new concepts that will help Timken and our customers make their mark for years to come. Innovation is one of our core values.

The return on our technology investment has grown exponentially. We help customers solve their immediate system issues, while developing the systems of tomorrow.

Our teams of engineers and scientists are dedicated to using everything they know about friction management and power transmission. They translate the scientific aspects of metallurgy, bearing operating characteristics, lubrication, torque, noise, heat-treatment, advanced processing concepts and application development into friction management solutions.

Because our teams are located at technology centers in North America, Europe and Asia – as well as in our manufacturing facilities and field offices on six continents – customers have access to ideas and resources that transform concepts into reality. Our technology focuses on products, materials, processes and emerging technology to create new solutions.

A BRAND YOU CAN TRUST

Timken has built a strong tradition of quality, technology and innovation. A long list of customer certifications provides solid evidence that our products have earned customer trust. As our founder, Henry Timken, said, "Don't set your name to anything you will ever have cause to be ashamed of."

From design to distribution, Timken gives customers expanded options and the security of knowing that each box contains an industry-tested product.

ABOUT THE TIMKEN COMPANY

The Timken Company is a diversified industrial manufacturer of innovative, highly engineered materials, products and power transmission systems. Timken's proprietary technologies reduce friction and enable machinery to operate more efficiently, powerfully and reliably, using less energy. With operations throughout the world, the company serves a wide range of mobile, industrial and aerospace customers.

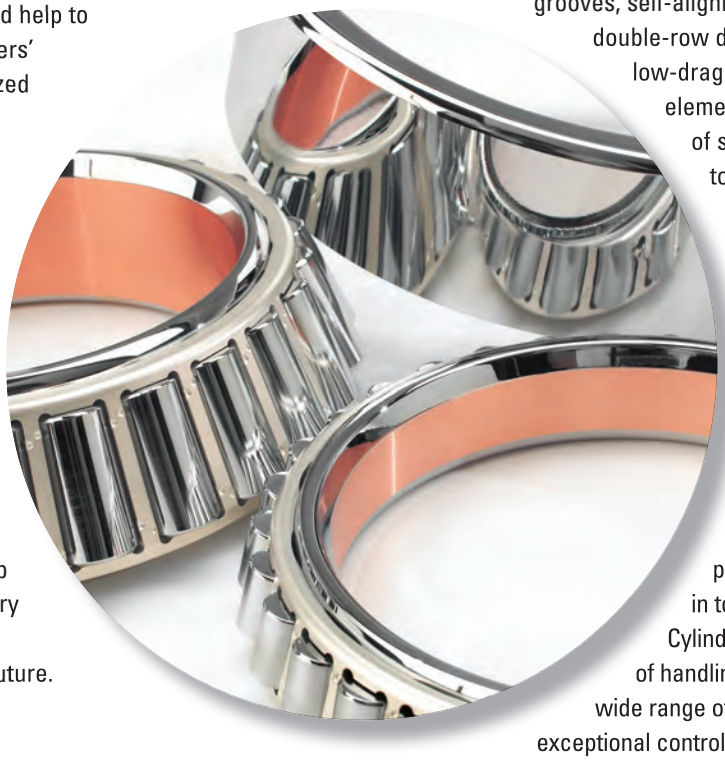
Timken has technical centers in North America, Europe and Asia and more than 100 years of engineering experience. Recognized by the Ethisphere Institute as among the 100 most ethical companies in the world in 2010, Timken has been listed on the New York Stock Exchange since 1922.

TIMKEN AEROSPACE SOLUTIONS

With rapidly expanding capabilities, Timken provides comprehensive life-cycle solutions and delivers unparalleled value for a growing number of aerospace power transmission systems. In addition to our global leadership position in aerospace bearings, we provide an increasing variety of products and services. These range from turbine engine components and gears to complete helicopter transmissions and services, which include part reconditioning and engine overhaul.

Customers around the world turn to Timken solutions for nearly every type of aerospace system – aircraft propulsion engines and auxiliary power units, gearboxes, helicopter transmissions, accessory subsystems, landing wheels, airframes and instrumentation. Our broad portfolio of products and services is known for consistent, critical performance and backed by stringent quality standards in the world.

We apply our advanced knowledge of friction management and power transmission to solve challenging motion-related problems and help to improve aerospace customers' performance. With specialized engineering and technical services, backed by significant ongoing investment in technology, we are a collaborator for design, testing and prototype development and continuing support. After more than 70 years as an aerospace innovator, Timken is well-equipped to supply the next-generation technologies needed to help keep commercial and military aircraft operating at peak performance well into the future.



PRODUCT BREADTH

Timken® Aerospace bearings are designed to meet the performance requirements of critical flight systems. Most bearings are made from vacuum-melt 52100 or VIM-VAR M-50 steel and are normally manufactured to ANSI/ABMA tolerance class 5 (ISO class 5), with high-strength machined cages. Other special materials are available for performance enhancement, and our expertise extends not only to the development and application of new materials but also to the heat-treatment processes necessary for demanding aerospace environments. A range of stainless alloy steels also is available.

While most aerospace bearings are based on standard configurations, the unique requirements of each application tend to result in a final design that incorporates some special features. Timken has the capability to manufacture bearings of all types up to 600 mm (23.62 in.) outside diameter (O.D.). Special designs can simplify mounting and improve performance. This might include features such as puller grooves, self-aligning seats, flange mounts, double-row duplex assemblies, oil grooves, low-drag seals or ceramic rolling elements. We also can apply a range of special coatings and platings to help reduce friction and wear, extend life and improve performance.

Various Timken ball bearing configurations are specially designed to handle radial, axial, moment, reversible axial or combination loads, as single units or preloaded sets. Instrument and thin-section ball bearings are designed to provide superior performance in torque-sensitive applications. Cylindrical roller bearings are capable of handling high radial loads and a wide range of application speeds through exceptional control of roller geometry.

Gears and associated components deliver power transmission value with a range that includes housings and associated parts such as shafts, adapters, covers, supports and retainers.

Turbine engine components from airfoils (nozzles, blades and vanes) to housings, ducts and related components help keep aircraft engines operating at peak performance levels.

Gearboxes and transmissions meet the demanding performance requirements for helicopter engine nose, main, intermediate and tail transmissions, as well as engine accessory gearboxes.

Rotorhead assemblies serve critical dynamic functions with hubs, swashplates and miscellaneous rotorhead components.

Bearing repair, based on Timken's unique capabilities, restores a wide range of types and sizes to original specifications, offering significant savings over the cost of new replacements.

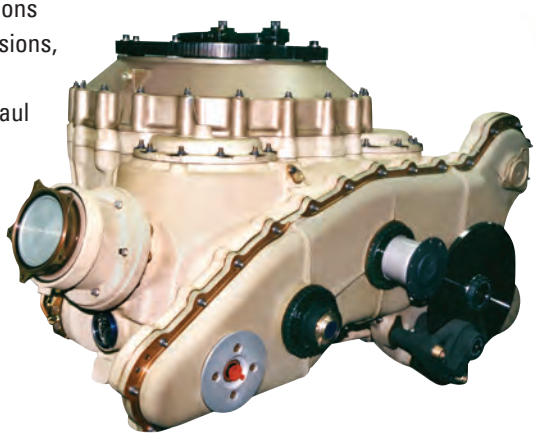
Component repair leverages Timken's core manufacturing strengths to return a wide range of parts to like-new condition for gas turbine engines and drivetrains.

Engine overhaul offers unmatched value for an increasing number of major aircraft platforms as part of our comprehensive lifecycle solutions.

Engineered surfaces improve wear and fatigue resistance for bearings and other components through a variety of applied treatments and finishes.

Frequently supplied with integral gears on their outer rings, spherical roller bearings are the preferred choice when operating conditions include heavy loads and difficulties with housing alignment or shaft deflection. Tapered roller bearings can withstand high accelerations and decelerations, heavy loads and a variety of temperature and environmental conditions. Aircraft landing wheel bearings are the standard in main and nose wheel assemblies for private, commercial and military planes.

As a Timken customer, you receive an uncompromising standard of quality across the broadest range of bearings and related products. Timken manufactures an extensive line of tapered, spherical, cylindrical and ball bearings, as well as mounted units, ideal for virtually every aerospace application. Our core products are complemented by an ever-growing line of friction management solutions including gears and transmissions, turbine engine components, replacement parts and overhaul services that help keep your aircraft flying.



ABOUT THIS DESIGN GUIDE

Timken offers an extensive range of bearings and accessories in both imperial and metric sizes. For your convenience, size ranges are indicated in millimeters and inches. Contact your Timken sales representative to learn more about our complete line for the special needs of your application.

USING THIS GUIDE

We are committed to providing our customers with maximum service and quality. This publication contains dimensions, tolerances and load ratings as well as an engineering section describing fitting practices for shafts and housings, internal clearances, materials and other bearing features. It can provide valuable assistance in the initial consideration of the type and characteristics of the bearing that may best suit your particular needs.

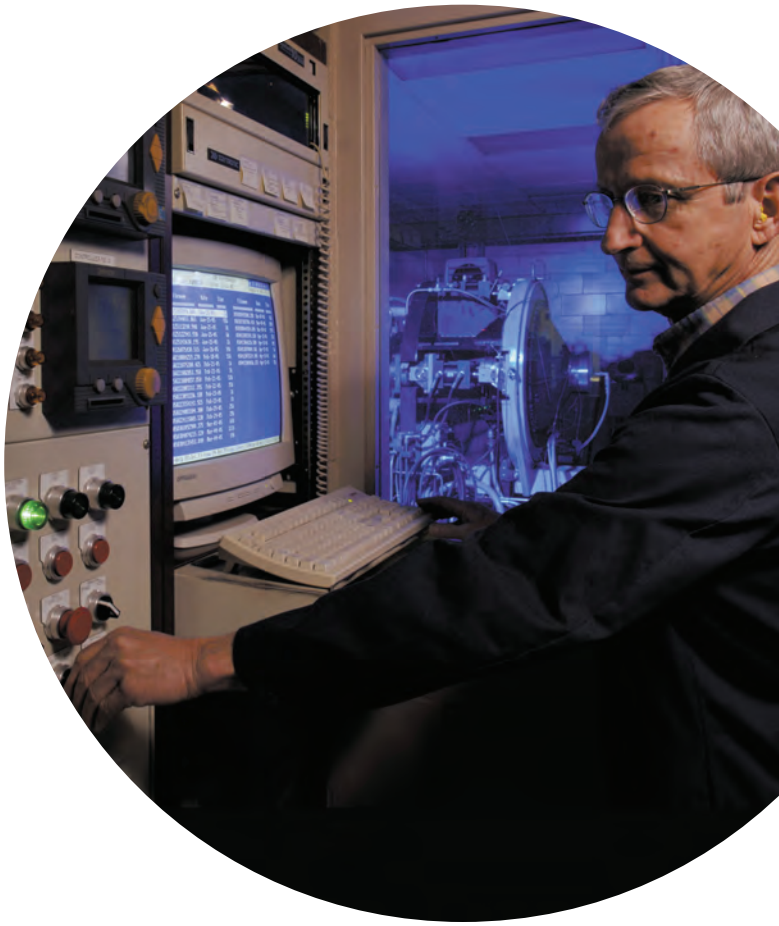
DESIGN GUIDE FEATURES

Dimensional and load rating data, within the various types and styles of bearings, is organized by size.

ISO and ANSI/ABMA, as used in this publication, refer to the International Organization for Standardization and the American National Standards Institute/American Bearing Manufacturers Association.

SPECIAL APPLICATIONS

Aerospace applications require some products made to special standards, and only original equipment manufacturers can determine if a particular bearing is suitable for use in their equipment.



⚠ WARNING

Failure to observe the following warnings could create a risk of serious injury.

Proper maintenance and handling practices are critical. Always follow installation instructions and maintain proper lubrication.

Every reasonable effort has been made to ensure the accuracy of the information contained in this design guide, but no liability is accepted for errors, omissions or for any other reason.

NOTE

Product performance is affected by many factors beyond the control of Timken. Therefore, you must validate the suitability and feasibility of all designs and product selection. This guide is provided solely to give you, a customer of Timken or its parent or affiliates, analysis tools and data to assist you in your design. No warranty, expressed or implied, including any warranty of merchantability or fitness for a particular purpose, is made by Timken. Timken products and services are sold subject to a Limited Warranty. You can see your Timken representative for more information.

SHELF LIFE AND STORAGE OF GREASE-LUBRICATED BEARINGS AND COMPONENTS

Timken guidelines for the shelf life of grease-lubricated rolling bearings, components and assemblies are set forth below. Shelf life information is based on test data and experience. Shelf life should be distinguished from lubricated bearing/component design life as follows:

SHELF LIFE

Shelf life of the grease-lubricated bearing/component represents the period of time prior to use or installation. The shelf life is a portion of the anticipated aggregate design life. It is impossible to accurately predict design life due to variations in lubricant bleed rates, oil migration, operating conditions, installation conditions, temperature, humidity and extended storage.

The bearing shelf life is related primarily to the lubricant's ability to maintain the bearing's original manufactured radial internal clearance and freedom to rotate.

The component shelf life is related to the ability of the component to function as originally intended.

Shelf life values, available from Timken, represent a maximum limit – and assume adherence to the Timken suggested storage and handling guidelines. Deviations from Timken's storage and handling guidelines may reduce shelf life. Any specification or operating practice that defines a shorter shelf life should be used. Timken cannot anticipate the performance of the grease lubricant after the bearing or component is installed or placed in service.

TIMKEN IS NOT RESPONSIBLE FOR THE SHELF LIFE OF ANY BEARING/COMPONENT LUBRICATED BY ANOTHER PARTY.

STORAGE

Timken suggests the following storage guidelines for its finished products (bearings, components and assemblies, hereinafter referred to as "Products"):

- Unless directed otherwise by Timken, Products should be kept in their original packaging until they are ready to be placed into service.
- Do not remove or alter any labels or stencil markings on the packaging.
- Products should be stored in such a way that the packaging is not pierced, crushed or otherwise damaged.
- After a Product is removed from its packaging, it should be placed into service as soon as possible.
- When removing a Product that is not individually packaged from a bulk pack container, the container should be resealed immediately after the Product is removed.
- Do not use Product that has exceeded its shelf life as defined in Timken's shelf life guidelines statement.
- The storage area temperature should be maintained between 0° C (32° F) and 40° C (104° F); temperature fluctuations should be minimized.
- The relative humidity should be maintained below 60 percent.
- The storage area should be kept free from airborne contaminants such as, but not limited to: dust, dirt, harmful vapors, etc.
- The storage area should be isolated from undue vibration.
- Extreme conditions of any kind should be avoided.

Inasmuch as Timken is not familiar with a customer's particular storage conditions, these guidelines are strongly suggested. However, the customer may very well be required by circumstance or applicable government requirements to adhere to stricter storage requirements.

Most bearing types are typically shipped protected with a corrosion-preventive compound that is not a lubricant. Such bearings may be used in oil-lubricated applications without removal of the corrosion-preventive compound. When using some specialized grease lubrication, it is advisable to remove the corrosion-preventive compound before packing the bearings with suitable grease.

Some bearing types in this design guide are pre-packed with general purpose grease suitable for their normal application. Frequent replenishment of the grease may be necessary for optimum performance. Care must be exercised in lubricant selection, however, since different lubricants are often incompatible.

When specified by the customer, other bearings may be ordered pre-lubricated with suitable greases and oils.

Upon receipt of a bearing shipment, ensure that the bearings are not removed from their packaging until they are ready for mounting so that they do not become corroded or contaminated. Bearings should be stored in an appropriate atmosphere in order that they remain protected for the intended period.

Any questions concerning shelf life or storage should be directed to your local sales office.

BEARING DESIGN

FROM APPLICATION TO SPECIFICATION – A LOGICAL APPROACH

This design guide is prepared to help you choose the optimum bearing for your specific application. Too often, bearings are selected without a thorough analysis, resulting in poor performance, unexpected problems and reduced life. To help you avoid these and other issues, Timken developed a four-step procedure to summarize key concepts that should be considered when developing an aerospace bearing specification. The interrelationship of these concepts covers the entire field of bearing engineering.

Although this design guide answers many questions, others may require the assistance of an experienced Timken engineer. Furthermore, in unusual or state-of-the-art applications, the solution may require a carefully monitored test program. Bearing chassis sizes and load ratings listed in this guide can be modified and optimized to meet specific requirements including special features.

STEP 1: DETERMINE PERFORMANCE REQUIREMENTS

Simply stated, two basic performance requirements control everything that a bearing must do within an application. Every bearing must:

1) Provide a defined level of rotational freedom.
2) Provide a defined level of position control (from basic free movement to high-frequency movement or vibration).

It is important to determine the actual limits of these requirements since bearing life is simply how long the bearing is statistically expected to operate within these limits. Of course, limits vary significantly from one type of application to another, so detailed analysis must be established.

STEP 2: DETERMINE APPLICATION PARAMETERS

A number of application parameters govern performance. Although only a portion may be significant in any given application, meticulous review of each will help ensure that nothing important has been overlooked.

Performance application parameters can be categorized four ways:

1) Physical.
2) Operational.
3) Environmental.
4) Economic.

In any given application, many of these are fixed while others are variable and can be modified or controlled when necessary. Final selection is always involves a balance of these parameters.

Physical Parameters

These include:

1) Space available for the bearing or bearing systems.
2) Allowable weight for the bearing or bearing systems.
3) The shape, material and tolerance control of the housing and shaft.
4) The features integrated into the bearing to simplify mounting structures.
5) Operational temperature.

The more space and weight allowed for the bearing system, the more sophisticated and reliable it will be. However, added weight may be an expensive luxury unless absolutely necessary, as would be true of supplementary lubrication systems for high-speed turbine and accessory bearings. The housing and shaft design has a significant impact on ultimate bearing performance. The shaft should be a solid, perfectly round cylinder made from material absolutely compatible with the thermal coefficient of expansion of the bearing. The housing cross section should be uniform, giving full hoop support for the bearing. Both housing and shaft should have precision-machined shoulders or seats to ensure perfect alignment.

Final design selection is made by choosing the best set of features to meet the physical parameters of the application. Timken engineers can provide design assistance in choosing the best design features for the application.

Operational Parameters

1) **Speed** governs the number of load cycles the bearing experiences and is, therefore, related to life. Speed, in terms of a relative guide parameter called “dN” (inner ring bore in mm x RPM), also influences many other aspects of bearing operation. This includes lubricant flow patterns and film thickness, centrifugal rolling element loads, skidding, excessive heat generation and lubrication method.
2) **Loads** break down in three directions: radial, axial and moment. These, in turn, can be applied as constant, variable, vibratory or impact loading. The combination must be carefully considered for optimum bearing life and performance.

Environmental Parameters

The environment is a fixed condition of the end product. However, the decision to protect or expose the bearing to the environment is a design option. Temperature, either ambient or internally generated, is a major consideration. The nature of the surrounding media, liquid or gas (for both materials and lubrication), may establish the need for seals, special corrosion protection or supplemental lubrication. Any special environments such as magnetic fields or radiation also should be considered for their design impact.

Economic Parameters

Total system cost should be carefully weighed. This is not just the cost of the bearing, but the total cost of bearing, mounting and replacement. Timken engineers can work with you on minimizing total system cost.

STEP 3: EVALUATE POTENTIAL DAMAGE MODES

Reduced design life in a particular application occurs when there is sufficient performance degradation so that the bearing no longer meets the original requirements. There are fifteen commonly identified primary damage modes:

1) Wear – foreign material.
2) Etching – corrosion.
3) Inadequate lubrication.
4) Fatigue spalling.
5) Excessive preload or overload.
6) Excessive endplay.
7) Misalignment and inaccurate machining of seats and shoulders.
8) Handling and installation damage.
9) Damaged bearing cages or retainers.
10) High spots and fitting practices.
11) Improper fit in housings or shafts.
12) Brinell and impact damage.
13) False brinelling.
14) Burns from electric current.
15) Cam fracture.

A complete discussion of these failure modes is beyond the scope of this design guide. It is important to note that only classic fatigue and true load brinell have specific formulas that permit calculation of life or numerical limit. All of the others are experience factors that are a function of the specific application, where temperatures, lubrication, overload or contamination are contributors to decreased life.

STEP 4: DETERMINE BEARING DESIGN

Only after careful consideration of the foregoing should a specific bearing selection be made. In many cases, it is possible to select a size and type from this guide without defining restrictions on other characteristics. In more critical applications, specific design decisions and/or controls can be developed based on:

1) Lubrication type, method and/or quantity.
2) Use of shields and/or seals.
3) Cage configurations, material and clearances.
4) Basic tolerance and modifications.
5) Radial play or contact angle.
6) Preload.
7) Material variation.
8) Contact area geometry modifications (curvature, crowning, etc.).
9) Special ball or roller complements.
10) Complete special and/or integral designs.

If the analysis has been completed properly, the final design should function as intended. Reliability and life expectancy will be optimized with the best chance of avoiding damage. Timken Aerospace engineers are ready to provide assistance as necessary to achieve this goal.

CONSTRUCTION SELECTION

CONSTRUCTION SELECTOR CHART

Evaluation of the design criteria contained in the following chart will help you choose the optimum design construction. While no individual construction can satisfy all possible service functions, proper selection makes it possible to meet the most critical functions or conditions in each application. The chart rates each construction on a relative basis.





Design Function	Deep-Groove HK Ball Bearing	Angular Contact HA/HJ Ball Bearing	Fractured Outer HD Ball Bearing	Two-Piece Inner HT Ball Bearing	Cylindrical Roller Radial Bearing
Radial load	S	M	E	S	E
Axial load – unidirectional	S	E	S[1]	E	M
Axial load – reversing	S	N/A	S[1]	E	N/A
Radial and unidirectional axial loads	S	E	E	S	M
Radial and reverse axial loads	S	N/A	E	S	N/A
Moment (cocking load)	S	N/A	M[1]	S	N/A
High speed	S	E	S [1]	E	E
Optimum design, one-piece cage	N/A	E	E	E	E
Ease of mounting	E	S	E	S	S
Ability to meet life with misalignment	E	M	E	S	M
Ability to absorb axial expansion with fixed rings	M	M	M	M	E

CODES: E = excellent S = satisfactory M = marginal N/A = not adequate or not available
[1] May be used with closely restraining housing fits and face clamping.

Table 1. Construction selector.

SIZE AND CHASSIS SELECTION

Timken Aerospace ball and roller bearings are offered in five basic boundary dimension series. These series, illustrated in Fig. 1 and listed in the dimension tables, include bearings ranging in size from 10 mm (0.3937 in.) bore to 600 mm (23.6220 in.) O.D. The 000 series (ANSI/ABMA 19 series) has become increasingly popular with the aircraft industry due to its very thin cross section and reduced weight. Timken also supplies bearings in the ultra-light 1800 series.

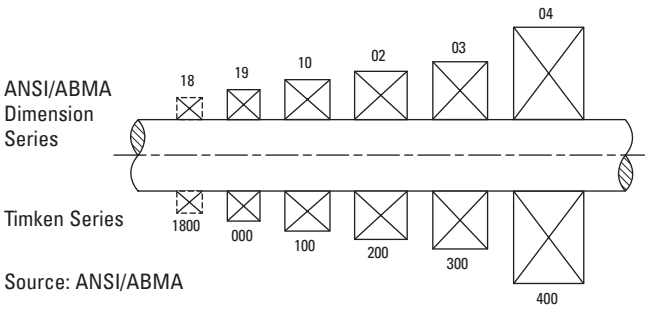


Fig. 1. ANSI/ABMA dimension series and Timken series.

SPECIAL DESIGNS

Many special designs can be made to simplify mounting and improve performance in complex engine assemblies.

A typical design would include bearings with puller grooves, self-aligning seats, flange mounts or double-row duplex assemblies. To speed delivery and reduce cost, all specialized bearings should be designed around standard bore, O.D. width or ball/roller complements as listed in the bearing specification tables.

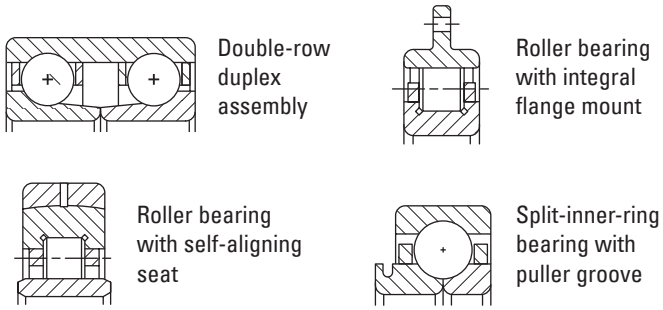


Fig. 2. Special designs.

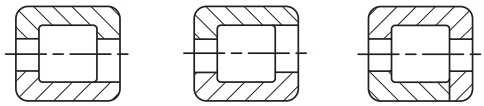
CYLINDRICAL ROLLER BEARINGS

BASIC CONSTRUCTION TYPES

Aerospace roller bearings are designed to meet the needs of high-speed operations. Careful attention to roller configuration, cage design, guide flange finish and contour and material stability can help you achieve roller end wear and improve life at high speeds.

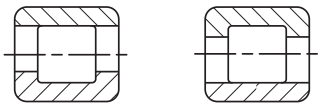
Conventionally designed roller bearings in standard 52100 or VIM-VAR M-50 steel are normally manufactured to class 5 tolerances with high-strength machined cages. Any of at least seven ring configurations may be selected, depending on the application. All types (except RAA) provide precision control of the roller for operation over a wide speed range with precision-ground, double-ribbed guide flanges on one ring. Generally, the guide flange diameters are ground to close tolerances to offer a riding surface for cage-to-land clearance control.

RF RJ RT



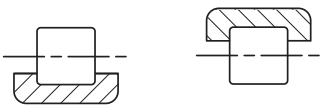
For applications requiring axial position control or limited axial capabilities in one direction, type RF is most frequently used. Under light loads, type RF is less prone to skidding. Under higher loads at higher speeds, type RJ is easier to lubricate with an oil jet onto the inner raceway. Type RT is similar, but can support a reversing or indeterminate thrust load.

RU RN



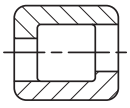
These full-floating configurations allow limited axial motion during operation. Type RU is easier to lubricate under heavy loads. Type RN is less prone to slip or skid under lighter or varying loads at high speeds.

RUS RNH



These configurations are used in integral designs where the rollers run directly on a hardened and ground shaft or housing. Nominal matching shaft and housing diameters are shown in the specification tables. Performance characteristics are similar to types RU and RN.

RAA



Single-ribbed inner and outer rings are a lower-cost version of type RF for use at low speeds or under oscillating conditions. This design generally has only guide flanges to accept some axial load in one direction (with well-lubricated guide flanges).

Fig. 3. Cylindrical roller bearing types.

ROLLERS

Rollers in all sizes over 3.5 mm (0.1378 in.) are contoured by crown blending for uniform stress distribution under load. The length is closely matched for uniform minimum clearance within the guide flanges to ensure optimum tracking at all speeds. All rollers listed in the specification tables have the preferred equal length-to-diameter ratio. These “square” rollers have superior ability to accept thrust and misalignment. Where theoretical capacity is critical and when load conditions and O.D. restrictions dictate, rollers of length-to-diameter ratio greater than 1 can be supplied.

CAGE OPTIONS

Following selection of the basic bearing construction, choosing the proper cage material results in the optimum bearing for the application. With the exception of the full roller complement, all cage options are one-piece designs with precision-machined pockets, piloted on the double-ribbed ring and are non-separable from the double-ribbed ring. Rollers are usually retained through a Timken-proprietary formed-tab design, although special designs may require the use of other retention methods.

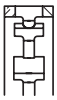
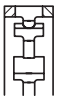
Cage Code	Material and Type	Design	Temp. Limit	Speed Limit dN 10^6	Description
F	Full roller complement, no cage		Same as bearing material	0.3	Use primarily at low speeds under high radial loads. Provides the maximum possible static load capacity. Also use to reduce cost where a cage is not required.
B	Machined brass		190° C 375° F	1.0	Use in heavily loaded transmission and accessory applications. Excellent strength and wear performance.
Z	AMS 4616 silicon-iron-bronze		260° C 500° F	1.5	Similar to brass with better strength and wear-resistant. Frequently used in combination with VIM-VAR M-50 rings where temperatures exceed the 177° C (350° F) limit for 52100 steel.
H	Machined and hardened AMS 6415 alloy steel silver-plated		480° C 900° F	3.0	Silver-plated to enhance run-in, wear life and to provide continuity after lubricant loss. VIM-VAR M-50 bearings with silver-plated steel cages are the first choice of the turbine industry for critical performance mainshaft and powertrain bearings.

Table 2. Cage options.

PART NUMBERS, DIMENSIONS AND LOAD RATINGS TABLE

CYLINDRICAL ROLLER BEARING SPECIFICATIONS

To develop a complete bearing part number:

1) Select MATERIALS AND OPERATING TEMPERATURES prefix (see page 40).
2) Select CONSTRUCTION TYPE and CAGE prefixes.

Cages		RF	RJ	RU	RN	RUS	RNH	RT
		Construction Types						
Full Roller Complement	F	RFF	RJF	RUF	RNF	RUSF	RNHF	RTF
Machined Brass	B	RFB	RJB	RUB	RNB	RUSB	RNHB	RTB
Machined Si-Fe Bronze	Z	RFZ	RJZ	RUZ	RNZ	RUSZ	RNHZ	RTZ
Machined Steel Silver-Plated	H	RFH	RJH	RUH	RNH	RUSH	RNHH	RTH

Table 3. Cylindrical roller bearing specifications.

3) Select basic bearing TIMKEN SIZE CODE. (See tables on pages 17-21.)
4) Timken adds a dash number to cover all other features, including tolerance class and radial play.

Examples		
	RFZ 201-103	5 RNF 109-28
Material	52100 steel	5 = VIM-VAR M-50 steel
Construction	RF = RF type	RN = RN type
Cage	Z = machined Si-Fe bronze	F = full roller complement
Size	201 = size 201	109 = size 109
	-103 = { special features detailed under "dash" 103 code	-28 = { special features detailed under "dash" 28 code

Table 4. Roller bearing part number examples.

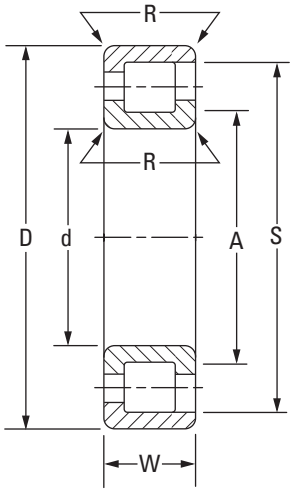


Fig. 4. Roller bearing dimensional features.

PART NUMBERS, DIMENSIONS AND LOAD RATINGS TABLE

Timken Size Code	Boundary Dimensions										Load Ratings	
	d	D	W	Mounting Shoulder Diameter		R	Nominal Roller Path Diameter		Roller		C_r	C_{or}
	Bore	Outside Diameter	Width	A	S	Radius					Dynamic Radial Capacity	Static Radial Capacity
				Min. Shaft	Max. Housing		Inner	Outer	No.	Diameter x Length		
	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.		mm in.	Newtons lbs.	Newtons lbs.
000	**10** 0.3937	**22** 0.8661	**6** 0.2362	**12.014** 0.473	**19.964** 0.786	**0.3** 0.012	**12.500** 0.4921	**19.500** 0.7677	10	**3.5 x 3.5** 0.1378 x 0.1378	**4790** 1080	**3480** 782
100	**10** 0.3937	**26** 1.0236	**8** 0.3150	**12.421** 0.489	**23.571** 0.928	**0.3** 0.012	**13.000** 0.5118	**23.000** 0.9055	8	**5 x 5** 0.1969 x 0.1969	**7950** 1790	**5580** 1250
200	**10** 0.3937	**30** 1.1811	**9** 0.3543	**14.021** 0.552	**25.984** 1.023	**0.6** 0.024	**15.000** 0.5906	**25.000** 0.9843	8	**5 x 5** 0.1969 x 0.1969	**8100** 1820	**5800** 1300
300	**10** 0.3937	**35** 1.3780	**11** 0.4331	**14.453** 0.569	**30.556** 1.203	**0.6** 0.024	**17.000** 0.6693	**30.000** 1.1811	8	**6.5 x 6.5** 0.2559 x 0.2559	**12700** 2860	**9240** 2080
001	**12** 0.4724	**24** 0.9449	**6** 0.2362	**14.021** 0.552	**21.996** 0.866	**0.3** 0.012	**14.676** 0.5778	**21.676** 0.8534	10	**3.5 x 3.5** 0.1378 x 0.1378	**4820** 1080	**3590** 808
101	**12** 0.4724	**28** 1.1024	**8** 0.3150	**14.326** 0.564	**25.679** 1.011	**0.3** 0.012	**15.000** 0.5906	**25.000** 0.9843	8	**5 x 5** 0.1969 x 0.1969	**8100** 1820	**5800** 1300
201	**12** 0.4724	**32** 1.2598	**10** 0.3937	**15.697** 0.618	**28.296** 1.114	**0.6** 0.024	**16.000** 0.6299	**28.000** 1.1024	8	**6 x 6** 0.2362 x 0.2362	**11400** 2560	**8280** 1860
301	**12** 0.4724	**37** 1.4567	**12** 0.4724	**17.043** 0.671	**32.029** 1.261	**1** 0.039	**18.034** 0.7100	**32.034** 1.2612	8	**7 x 7** 0.2756 x 0.2756	**14700** 3300	**10800** 2430
002	**15** 0.5906	**28** 1.1024	**7** 0.2756	**17.043** 0.671	**25.959** 1.022	**0.3** 0.012	**18.000** 0.7087	**25.000** 0.9843	14	**3.5 x 3.5** 0.1378 x 0.1378	**6180** 1390	**5220** 1170
102	**15** 0.5906	**32** 1.2598	**9** 0.3543	**17.424** 0.686	**29.591** 1.165	**0.3** 0.012	**18.750** 0.7382	**28.750** 1.1319	10	**5 x 5** 0.1969 x 0.1969	**9750** 2190	**7630** 1710
202	**15** 0.5906	**35** 1.3780	**11** 0.4331	**18.542** 0.730	**31.471** 1.239	**0.6** 0.024	**19.000** 0.7480	**31.000** 1.2205	10	**6 x 6** 0.2362 x 0.2362	**13800** 3090	**10800** 2430
302	**15** 0.5906	**42** 1.6535	**13** 0.5118	**20.218** 0.796	**36.906** 1.453	**1** 0.039	**20.900** 0.8228	**36.900** 1.4528	8	**8 x 8** 0.3150 x 0.3150	**19100** 4300	**14400** 3240
003	**17** 0.6693	**30** 1.1811	**7** 0.2756	**19.025** 0.749	**27.991** 1.102	**0.3** 0.012	**20.000** 0.7874	**27.000** 1.0630	14	**3.5 x 3.5** 0.1378 x 0.1378	**6150** 1380	**5300** 1190
103	**17** 0.6693	**35** 1.3780	**10** 0.3937	**19.380** 0.763	**32.614** 1.284	**0.3** 0.012	**21.250** 0.8366	**31.250** 1.2303	12	**5 x 5** 0.1969 x 0.1969	**11200** 2520	**9380** 2110
203	**17** 0.6693	**40** 1.5748	**12** 0.4724	**20.701** 0.815	**36.297** 1.429	**0.6** 0.024	**22.324** 0.8789	**35.324** 1.3907	10	**6.5 x 6.5** 0.2559 x 0.2559	**15500** 3480	**12400** 2780
303	**17** 0.6693	**47** 1.8504	**14** 0.5512	**22.327** 0.879	**41.681** 1.641	**1** 0.039	**23.451** 0.9233	**41.451** 1.6319	8	**9 x 9** 0.3543 x 0.3543	**24100** 5410	**18500** 4160
403	**17** 0.6693	**62** 2.4409	**17** 0.6693	**24.028** 0.946	**54.966** 2.164	**1** 0.039	**28.500** 1.1220	**50.500** 1.9882	8	**11 x 11** 0.4331 x 0.4331	**34200** 7680	**26900** 6050
004	**20** 0.7874	**37** 1.4567	**9** 0.3543	**22.200** 0.874	**34.798** 1.370	**0.3** 0.012	**23.749** 0.9350	**33.749** 1.3287	14	**5 x 5** 0.1969 x 0.1969	**12600** 2830	**11200** 2510
104	**20** 0.7874	**42** 1.6535	**12** 0.4724	**23.546** 0.927	**38.456** 1.514	**0.6** 0.024	**24.000** 0.9449	**38.000** 1.4961	10	**7 x 7** 0.2756 x 0.2756	**17900** 4030	**14500** 3260
204	**20** 0.7874	**47** 1.8504	**14** 0.5512	**24.689** 0.972	**42.291** 1.665	**1** 0.039	**25.900** 1.0197	**41.900** 1.6496	10	**8 x 8** 0.3150 x 0.3150	**23200** 5220	**19100** 4280
304	**20** 0.7874	**52** 2.0472	**15** 0.5906	**25.197** 0.992	**46.812** 1.843	**1** 0.039	**26.000** 1.0236	**46.000** 1.8110	8	**10 x 10** 0.3937 x 0.3937	**29500** 6630	**23100** 5190
404	**20** 0.7874	**72** 2.8346	**19** 0.7480	**27.026** 1.064	**64.973** 2.558	**1** 0.039	**34.000** 1.3386	**58.000** 2.2834	8	**12 x 12** 0.4724 x 0.4724	**41000** 9220	**33200** 7460
005	**25** 0.9843	**42** 1.6535	**9** 0.3543	**27.178** 1.070	**39.827** 1.568	**0.3** 0.012	**29.017** 1.1424	**39.017** 1.5361	16	**5 x 5** 0.1969 x 0.1969	**13800** 3100	**13200** 2960
105	**25** 0.9843	**47** 1.8504	**12** 0.4724	**28.651** 1.128	**43.332** 1.706	**0.6** 0.024	**29.000** 1.1417	**43.000** 1.6929	12	**7 x 7** 0.2756 x 0.2756	**20700** 4660	**18100** 4070
205	**25** 0.9843	**52** 2.0472	**15** 0.5906	**29.616** 1.166	**47.396** 1.866	**1** 0.039	**30.482** 1.2000	**46.482** 1.8300	12	**8 x 8** 0.3150 x 0.3150	**26900** 6040	**23700** 5330
305	**25** 0.9843	**62** 2.4409	**17** 0.6693	**30.607** 1.205	**56.388** 2.220	**1** 0.039	**33.564** 1.3214	**55.564** 2.1876	10	**11 x 11** 0.4331 x 0.4331	**41200** 9270	**35100** 7890
405	**25** 0.9843	**80** 3.1496	**21** 0.8268	**33.096** 1.303	**71.907** 2.831	**1.5** 0.059	**39.500** 1.5551	**65.500** 2.5787	10	**13 x 13** 0.5118 x 0.5118	**57100** 12800	**50000** 11300

R = maximum shaft or housing fillet radius that bearing corner will clear.
C_r = ANSI/ABMA dynamic radial load rating (33⅓ RPM for 500 hours and 90 percent survival, equivalent to 1000000 inner ring revolutions).
C_{or} = ANSI/ABMA static radial load rating.

continued on next page

PART NUMBERS, DIMENSIONS AND LOAD RATINGS TABLE continued

Timken Size Code	Boundary Dimensions										Load Ratings	
	d	D	W	Mounting Shoulder Diameter		R	Nominal Roller Path Diameter		Roller		C_r	C_{or}
	Bore	Outside Diameter	Width	A	S	Radius					Dynamic Radial Capacity	Static Radial Capacity
				Min. Shaft	Max. Housing		Inner	Outer	No.	Diameter x Length		
	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.		mm in.	Newtons lbs.	Newtons lbs.
006	**30** 1.1811	**47** 1.8504	**9** 0.3543	**32.207** 1.268	**44.806** 1.764	**0.3** 0.012	**33.749** 1.3287	**43.749** 1.7224	18	**5 x 5** 0.1969 x 0.1969	**14900** 3350	**15100** 3400
106	**30** 1.1811	**55** 2.1654	**13** 0.5118	**34.544** 1.360	**50.470** 1.987	**1** 0.039	**35.850** 1.4114	**49.850** 1.9626	14	**7 x 7** 0.2756 x 0.2756	**23200** 5220	**22000** 4940
206	**30** 1.1811	**62** 2.4409	**16** 0.6299	**34.900** 1.374	**57.099** 2.248	**1** 0.039	**37.020** 1.4575	**57.020** 2.2449	12	**10 x 10** 0.3937 x 0.3937	**41400** 9310	**37800** 8490
306	**30** 1.1811	**72** 2.8346	**19** 0.7480	**35.890** 1.413	**66.091** 2.602	**1** 0.039	**38.651** 1.5217	**64.651** 2.5453	10	**13 x 13** 0.5118 x 0.5118	**56900** 12800	**49800** 11200
406	**30** 1.1811	**90** 3.5433	**23** 0.9055	**38.100** 1.500	**81.915** 3.225	**1.5** 0.059	**46.000** 1.8110	**74.000** 2.9134	10	**14 x 14** 0.5512 x 0.5512	**66400** 14900	**59600** 13400
007	**35** 1.3780	**55** 2.1654	**10** 0.3937	**38.354** 1.510	**51.664** 2.034	**0.6** 0.024	**39.300** 1.5472	**51.300** 2.0197	18	**6 x 6** 0.2362 x 0.2362	**21300** 4790	**22200** 5000
107	**35** 1.3780	**62** 2.4409	**14** 0.5512	**39.624** 1.560	**57.379** 2.259	**1** 0.039	**40.900** 1.6102	**56.900** 2.2402	14	**8 x 8** 0.3150 x 0.3150	**30200** 6790	**29200** 6570
207	**35** 1.3780	**72** 2.8346	**17** 0.6693	**40.361** 1.589	**66.624** 2.623	**1** 0.039	**43.050** 1.6949	**65.050** 2.5610	12	**11 x 11** 0.4331 x 0.4331	**48100** 10800	**44500** 10000
307	**35** 1.3780	**80** 3.1496	**21** 0.8268	**42.748** 1.683	**72.238** 2.844	**1.5** 0.059	**43.500** 1.7126	**71.500** 2.8150	10	**14 x 14** 0.5512 x 0.5512	**66100** 14900	**58900** 13200
407	**35** 1.3780	**100** 3.9370	**25** 0.9843	**43.104** 1.697	**91.923** 3.619	**1.5** 0.059	**52.500** 2.0669	**82.500** 3.2481	10	**15 x 15** 0.5906 x 0.5906	**76300** 17100	**70000** 15700
008	**40** 1.5748	**62** 2.4409	**12** 0.4724	**43.358** 1.707	**58.649** 2.309	**0.6** 0.024	**44.000** 1.7323	**58.000** 2.2835	18	**7 x 7** 0.2756 x 0.2756	**27700** 6230	**29100** 6540
108	**40** 1.5748	**68** 2.6772	**15** 0.5906	**44.577** 1.755	**63.424** 2.497	**1** 0.039	**45.000** 1.7717	**63.000** 2.4803	14	**9 x 9** 0.3543 x 0.3543	**38000** 8540	**37400** 8400
208	**40** 1.5748	**80** 3.1496	**18** 0.7087	**45.542** 1.793	**74.447** 2.931	**1** 0.039	**48.600** 1.9134	**72.600** 2.8583	12	**12 x 12** 0.4724 x 0.4724	**57100** 12800	**54000** 12100
308	**40** 1.5748	**90** 3.5433	**23** 0.9055	**48.133** 1.895	**81.864** 3.223	**1.5** 0.059	**49.800** 1.9606	**81.800** 3.2205	10	**16 x 16** 0.6299 x 0.6299	**85600** 19200	**77900** 17500
408	**40** 1.5748	**110** 4.3307	**27** 1.0630	**50.495** 1.988	**99.517** 3.918	**2** 0.079	**58.000** 2.2835	**92.000** 3.6221	10	**17 x 17** 0.6693 x 0.6693	**93100** 20900	**86000** 19300
009	**45** 1.7717	**68** 2.6772	**12** 0.4724	**48.590** 1.913	**64.414** 2.536	**0.6** 0.024	**49.500** 1.9488	**63.500** 2.5000	20	**7 x 7** 0.2756 x 0.2756	**29700** 6680	**32800** 7380
109	**45** 1.7717	**75** 2.9528	**16** 0.6299	**49.759** 1.959	**70.231** 2.765	**1** 0.039	**51.450** 2.0256	**69.450** 2.7342	16	**9 x 9** 0.3543 x 0.3543	**41800** 9390	**43600** 9800
209	**45** 1.7717	**85** 3.3465	**19** 0.7480	**50.419** 1.985	**79.578** 3.133	**1** 0.039	**52.650** 2.0728	**78.650** 3.0965	12	**13 x 13** 0.5118 x 0.5118	**66700** 15000	**64000** 14400
309	**45** 1.7717	**100** 3.9370	**25** 0.9843	**53.001** 2.087	**91.999** 3.622	**1.5** 0.059	**55.500** 2.1850	**89.500** 3.5236	10	**17 x 17** 0.6693 x 0.6693	**92900** 20900	**85100** 19100
409	**45** 1.7717	**120** 4.7244	**29** 1.1417	**55.499** 2.185	**109.499** 4.311	**2** 0.079	**64.500** 2.5394	**100.500** 3.9568	12	**18 x 18** 0.7087 x 0.7087	**120000** 27000	**118000** 26500
010	**50** 1.9685	**72** 2.8346	**12** 0.4724	**53.569** 2.109	**68.453** 2.695	**0.6** 0.024	**54.000** 2.1260	**68.000** 2.6772	20	**7 x 7** 0.2756 x 0.2756	**29400** 6620	**33200** 7460
110	**50** 1.9685	**80** 3.1496	**16** 0.6299	**54.788** 2.157	**75.209** 2.961	**1** 0.039	**56.449** 2.2224	**74.449** 2.9311	18	**9 x 9** 0.3543 x 0.3543	**45300** 10200	**49700** 11200
210	**50** 1.9685	**90** 3.5433	**20** 0.7874	**55.372** 2.180	**84.633** 3.332	**1** 0.039	**57.650** 2.2697	**83.650** 3.2933	14	**13 x 13** 0.5118 x 0.5118	**75000** 16900	**76000** 17100
310	**50** 1.9685	**110** 4.3307	**27** 1.0630	**59.715** 2.351	**100.279** 3.948	**2** 0.079	**61.950** 2.4390	**99.950** 3.9350	10	**19 x 19** 0.7480 x 0.7480	**115000** 25900	**108000** 24300
410	**50** 1.9685	**130** 5.1181	**31** 1.2205	**63.957** 2.518	**116.053** 4.569	**2** 0.079	**71.000** 2.7953	**109.000** 4.2913	12	**19 x 19** 0.7480 x 0.7480	**134000** 30000	**133000** 30000
011	**55** 2.1654	**80** 3.1496	**13** 0.5118	**60.071** 2.365	**74.930** 2.950	**1** 0.039	**60.850** 2.3957	**74.850** 2.9468	24	**7 x 7** 0.2756 x 0.2756	**33200** 7470	**40300** 9070
111	**55** 2.1654	**90** 3.5433	**18** 0.7087	**60.909** 2.398	**84.099** 3.311	**1** 0.039	**62.049** 2.4429	**84.049** 3.3090	16	**11 x 11** 0.4331 x 0.4331	**59400** 13300	**63300** 14200
211	**55** 2.1654	**100** 3.9370	**21** 0.8268	**62.128** 2.446	**92.888** 3.657	**1.5** 0.059	**63.500** 2.5000	**91.500** 3.6024	14	**14 x 14** 0.5512 x 0.5512	**86600** 19500	**89200** 20100
311	**55** 2.1654	**120** 4.7244	**29** 1.1417	**64.973** 2.558	**110.033** 4.332	**2** 0.079	**69.449** 2.7342	**107.449** 4.2303	12	**19 x 19** 0.7480 x 0.7480	**133000** 30000	**133000** 29900
411	**55** 2.1654	**140** 5.5118	**33** 1.2992	**68.961** 2.715	**126.035** 4.962	**2** 0.079	**77.500** 3.0512	**117.500** 4.6260	12	**20 x 20** 0.7874 x 0.7874	**148000** 33200	**150000** 33700

R = maximum shaft or housing fillet radius that bearing corner will clear.
C_r = ANSI/ABMA dynamic radial load rating (33⅓ RPM for 500 hours and 90 percent survival, equivalent to 1000000 inner ring revolutions).
C_{or} = ANSI/ABMA static radial load rating.

Timken Size Code	Boundary Dimensions										Load Ratings	
	d	D	W	Mounting Shoulder Diameter		R	Nominal Roller Path Diameter		Roller		C_r	C_{or}
	Bore	Outside Diameter	Width	A	S	Radius	Inner	Outer	No.	Diameter x Length	Dynamic Radial Capacity	Static Radial Capacity
				Min. Shaft	Max. Housing							
	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.		mm in.	Newtons lbs.	Newtons lbs.
012	**60** 2.3622	**85** 3.3465	**13** 0.5118	**65.024** 2.560	**79.959** 3.148	**1** 0.039	**65.723** 2.5875	**79.723** 3.1387	24	**7 x 7** 0.2756 x 0.2756	**32900** 7390	**40700** 9140
112	**60** 2.3622	**95** 3.7402	**18** 0.7087	**65.837** 2.592	**89.154** 3.510	**1** 0.039	**66.500** 2.6181	**88.500** 3.4842	18	**11 x 11** 0.4331 x 0.4331	**64600** 14500	**72000** 16200
212	**60** 2.3622	**110** 4.3307	**22** 0.8661	**67.259** 2.648	**102.743** 4.045	**1.5** 0.059	**69.800** 2.7480	**101.800** 4.0079	14	**16 x 16** 0.6299 x0.6299	**112000** 25200	**117000** 26400
312	**60** 2.3622	**130** 5.1181	**31** 1.2205	**70.231** 2.765	**119.786** 4.716	**2** 0.079	**75.000** 2.9528	**115.000** 4.5276	12	**20 x 20** 0.7874 x 0.7874	**148000** 33200	**149000** 33500
412	**60** 2.3622	**150** 5.9055	**35** 1.3780	**73.965** 2.912	**136.042** 5.356	**2** 0.079	**83.000** 3.2678	**127.000** 5.0000	12	**22 x 22** 0.8661 x 0.8661	**178000** 39900	**182000** 41000
013	**65** 2.5591	**90** 3.5433	**13** 0.5118	**69.977** 2.755	**85.014** 3.347	**1** 0.039	**70.500** 2.7756	**84.500** 3.3268	26	**7 x 7** 0.2756 x 0.2756	**34600** 7770	**44300** 9970
113	**65** 2.5591	**100** 3.9370	**18** 0.7087	**70.790** 2.787	**94.209** 3.709	**1** 0.039	**71.500** 2.8150	**93.500** 3.6811	18	**11 x 11** 0.4331 x 0.4331	**64200** 14400	**72700** 16300
213	**65** 2.5591	**120** 4.7244	**23** 0.9055	**72.593** 2.858	**112.420** 4.426	**1.5** 0.059	**77.299** 3.0433	**109.299** 4.3031	14	**16 x 16** 0.6299 x 0.6299	**112000** 25200	**119000** 26900
313	**65** 2.5591	**140** 5.5118	**33** 1.2992	**74.905** 2.949	**130.099** 5.122	**2** 0.079	**81.600** 3.2126	**125.600** 4.9449	12	**22 x 22** 0.8661 x 0.8661	**178000** 39900	**182000** 40900
413	**65** 2.5591	**160** 6.2992	**37** 1.4587	**78.969** 3.109	**146.050** 5.750	**2** 0.079	**89.500** 3.5237	**135.500** 5.3347	12	**23 x 23** 0.9055 x 0.9055	**194000** 43600	**202000** 45300
014	**70** 2.7559	**100** 3.9370	**16** 0.6299	**75.260** 2.963	**94.742** 3.730	**1** 0.039	**76.449** 3.0098	**94.449** 3.7185	24	**9 x 9** 0.3543 x 0.3543	**54400** 12200	**68800** 15500
114	**70** 2.7559	**110** 4.3307	**20** 0.7874	**76.048** 2.994	**103.937** 4.092	**1** 0.039	**77.000** 3.0315	**103.000** 4.0551	18	**13 x 13** 0.5118 x 0.5118	**89600** 20100	**102000** 23000
214	**70** 2.7559	**125** 4.9213	**24** 0.9449	**77.572** 3.054	**117.424** 4.623	**1.5** 0.059	**80.500** 3.1693	**114.500** 4.5079	14	**17 x 17** 0.6693 x 0.6693	**121000** 27200	**129000** 28900
314	**70** 2.7559	**150** 5.9055	**35** 1.3780	**81.153** 3.195	**138.836** 5.466	**2** 0.079	**87.200** 3.4331	**135.200** 5.3228	12	**24 x 24** 0.9449 x 0.9449	**210000** 47200	**217000** 48900
414	**70** 2.7559	**180** 7.0866	**42** 1.6535	**87.503** 3.445	**162.484** 6.397	**2.5** 0.098	**99.000** 3.8977	**151.000** 5.9449	12	**26 x 26** 1.0236 x 1.0236	**239000** 53700	**251000** 56400
015	**75** 2.9528	**105** 4.1339	**16** 0.6299	**80.289** 3.161	**99.720** 3.926	**1** 0.039	**81.000** 3.1890	**99.000** 3.8976	24	**9 x 9** 0.3543 x 0.3543	**54100** 12200	**69200** 15500
115	**75** 2.9528	**115** 4.5276	**20** 0.7874	**81.026** 3.190	**108.966** 4.290	**1** 0.039	**82.000** 3.2283	**108.000** 4.2520	18	**13 x 13** 0.5118 x 0.5118	**89200** 20100	**103000** 23200
215	**75** 2.9528	**130** 5.1181	**25** 0.9843	**82.550** 3.250	**122.428** 4.820	**1.5** 0.059	**84.500** 3.3268	**120.500** 4.7441	14	**18 x 18** 0.7087 x 0.7087	**135000** 30400	**145000** 32600
315	**75** 2.9528	**160** 6.2992	**37** 1.4567	**86.436** 3.403	**148.565** 5.849	**2** 0.079	**92.800** 3.6535	**144.800** 5.7008	12	**26 x 26** 1.0236 x 1.0236	**238000** 53500	**247000** 55600
415	**75** 2.9528	**190** 7.4803	**45** 1.7717	**92.507** 3.642	**172.491** 6.791	**2.5** 0.098	**104.501** 4.1142	**160.501** 6.3190	12	**28 x 28** 1.1024 x 1.1024	**276000** 62000	**292000** 65700
016	**80** 3.1496	**110** 4.3307	**16** 0.6299	**85.242** 3.356	**104.750** 4.124	**1** 0.039	**86.000** 3.3858	**104.000** 4.0945	26	**9 x 9** 0.3543 x 0.3543	**56900** 12800	**75400** 16900
116	**80** 3.1496	**125** 4.9213	**22** 0.8661	**86.081** 3.389	**118.923** 4.682	**1** 0.039	**89.500** 3.5236	**115.500** 4.5472	20	**13 x 13** 0.5118 x 0.5118	**95900** 21500	**116000** 26100
216	**80** 3.1496	**140** 5.5118	**26** 1.0236	**89.383** 3.519	**130.607** 5.142	**2** 0.079	**92.000** 3.6220	**128.000** 5.0394	16	**18 x 18** 0.7087 x 0.7087	**149000** 33600	**168000** 37800
316	**80** 3.1496	**170** 6.6929	**39** 1.5354	**91.719** 3.611	**158.293** 6.232	**2** 0.079	**99.368** 3.9121	**155.368** 6.1169	12	**28 x 28** 1.1024 x 1.1024	**275000** 61800	**289000** 65000
416	**80** 3.1496	**200** 7.8740	**48** 1.8898	**97.511** 3.839	**182.499** 7.185	**2.5** 0.098	**110.000** 4.3307	**170.000** 6.6929	12	**30 x 30** 1.1811 x 1.1811	**315000** 70800	**337000** 75700
017	**85** 3.3465	**120** 4.7244	**18** 0.7087	**90.703** 3.571	**114.300** 4.500	**1** 0.039	**92.049** 3.6240	**114.049** 4.4901	24	**11 x 11** 0.4331 x 0.4331	**77500** 17400	**99900** 22500
117	**85** 3.3465	**130** 5.1181	**22** 0.8661	**91.262** 3.593	**123.749** 4.872	**1** 0.039	**93.500** 3.6811	**121.500** 4.7835	20	**14 x 14** 0.5512 x 0.5512	**111000** 24900	**135000** 30400
217	**85** 3.3465	**150** 5.9055	**28** 1.1024	**94.513** 3.721	**140.487** 5.531	**2** 0.079	**98.499** 3.8779	**138.499** 5.4527	14	**20 x 20** 0.7874 x 0.7874	**166000** 37300	**183000** 41100
317	**85** 3.3465	**180** 7.0866	**41** 1.6142	**98.450** 3.876	**166.548** 6.557	**2.5** 0.098	**104.500** 4.1142	**160.500** 6.3189	12	**28 x 28** 1.1024 x 1.1024	**276000** 62000	**292000** 65700
417	**85** 3.3465	**210** 8.2677	**52** 2.0472	**107.772** 4.243	**187.249** 7.372	**3** 0.118	**115.500** 4.5473	**179.500** 7.0669	12	**32 x 32** 1.2598 x 1.2598	**356000** 80100	**384000** 86400

R = maximum shaft or housing fillet radius that bearing corner will clear.
C_r = ANSI/ABMA dynamic radial load rating (33⅓ RPM for 500 hours and 90 percent survival, equivalent to 1000000 inner ring revolutions).
C_{or} = ANSI/ABMA static radial load rating.

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PART NUMBERS, DIMENSIONS AND LOAD RATINGS TABLE continued

Timken Size Code	Boundary Dimensions										Load Ratings	
	d	D	W	Mounting Shoulder Diameter		R	Nominal Roller Path Diameter		Roller		C_r	C_{or}
	Bore	Outside Diameter	Width	A	S	Radius					Dynamic Radial Capacity	Static Radial Capacity
				Min. Shaft	Max. Housing		Inner	Outer	No.	Diameter x Length		
	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.		mm in.	Newtons lbs.	Newtons lbs.
018	**90** 3.5433	**125** 4.9213	**18** 0.7087	**95.682** 3.767	**119.329** 4.698	**1** 0.039	**97.050** 3.8209	**119.050** 4.6870	24	**11 x 11** 0.4331 x 0.4331	**77000** 17300	**100000** 22600
118	**90** 3.5433	**140** 5.5118	**24** 0.9449	**97.587** 3.842	**132.410** 5.213	**1.5** 0.059	**100.749** 3.9665	**130.749** 5.1476	20	**15 x 15** 0.5906 x 0.5906	**127000** 28500	**157000** 35200
218	**90** 3.5433	**160** 6.2992	**30** 1.1811	**100.863** 3.971	**149.149** 5.872	**2** 0.079	**105.000** 4.1339	**145.000** 5.7087	16	**20 x 20** 0.7874 x 0.7874	**183000** 41200	**211000** 47500
318	**90** 3.5433	**190** 7.4803	**43** 1.6929	**103.759** 4.085	**176.251** 6.939	**2.5** 0.098	**111.501** 4.3898	**171.501** 6.7520	12	**30 x 30** 1.1811 x 1.1811	**315000** 70800	**338000** 75900
418	**90** 3.5433	**225** 8.8583	**54** 2.1260	**112.751** 4.439	**202.235** 7.962	**3** 0.118	**123.500** 4.8622	**191.500** 7.5394	12	**34 x 34** 1.3386 x 1.3386	**401000** 90100	**437000** 98300
019	**95** 3.7402	**130** 5.1181	**18** 0.7087	**100.711** 3.965	**124.282** 4.893	**1** 0.039	**102.050** 4.0177	**124.050** 4.8839	26	**11 x 11** 0.4331 x0.4331	**81200** 18300	**109000** 24600
119	**95** 3.7402	**145** 5.7087	**24** 0.9449	**102.591** 4.039	**137.414** 5.410	**1.5** 0.059	**104.800** 4.1260	**136.800** 5.3858	20	**16 x 16** 0.6299 x 0.6299	**144000** 32300	**179000** 40200
219	**95** 3.7402	**170** 6.6929	**32** 1.2598	**106.197** 4.181	**158.801** 6.252	**2** 0.079	**111.600** 4.3937	**155.600** 6.1260	16	**22 x 22** 0.8661 x 0.8661	**221000** 49600	**257000** 57800
319	**95** 3.7402	**200** 7.8740	**45** 1.7717	**109.068** 4.294	**185.928** 7.320	**2.5** 0.098	**117.099** 4.6102	**181.099** 7.1299	12	**32 x 32** 1.2598 x 1.2598	**356000** 80100	**386000** 86700
419	**95** 3.7402	**240** 9.4488	**55** 2.1654	**117.754** 4.636	**217.246** 8.553	**3** 0.118	**132.500** 5.2165	**202.500** 7.9725	12	**35 x 35** 1.3780 x 1.3780	**416000** 93400	**456000** 103000
020	**100** 3.9370	**140** 5.5118	**20** 0.7874	**105.969** 4.172	**134.036** 5.277	**1** 0.039	**108.000** 4.2520	**132.000** 5.1968	24	**12 x 12** 0.4724 x 0.4724	**91100** 20500	**121000** 27300
120	**100** 3.9370	**150** 5.9055	**24** 0.9449	**107.442** 4.230	**142.545** 5.612	**1.5** 0.059	**109.800** 4.3228	**141.800** 5.5827	20	**16 x 16** 0.6299 x 0.6299	**143000** 32200	**180000** 40400
220	**100** 3.9370	**180** 7.0866	**34** 1.3386	**111.531** 4.391	**168.478** 6.633	**2** 0.079	**115.000** 4.5275	**165.000** 6.4960	14	**25 x 25** 0.9843 x 0.9843	**249000** 56000	**279000** 62700
320	**100** 3.9370	**215** 8.4646	**47** 1.8504	**115.976** 4.566	**199.009** 7.835	**2.5** 0.098	**123.300** 4.8543	**195.300** 7.6890	10	**36 x 36** 1.4173 x 1.4173	**380000** 85500	**395000** 88700
420	**100** 3.9370	**250** 9.8424	**58** 2.2835	**122.758** 4.833	**227.228** 8.946	**3** 0.118	**139.000** 5.4724	**211.000** 8.3070	12	**36 x 36** 1.4173 x 1.4173	**439000** 98800	**486000** 109000
021	**105** 4.1339	**145** 5.7087	**20** 0.7874	**110.947** 4.368	**139.040** 5.474	**1** 0.039	**113.000** 4.4488	**137.000** 5.3937	24	**12 x 12** 0.4724 x 0.4724	**90500** 20300	**122000** 27400
121	**105** 4.1339	**160** 6.2992	**26** 1.0236	**114.859** 4.522	**150.139** 5.911	**2** 0.079	**116.350** 4.5807	**150.350** 5.9193	20	**17 x 17** 0.6693 x 0.6693	**155000** 34800	**194000** 43600
221	**105** 4.1339	**190** 7.4803	**36** 1.4173	**116.865** 4.601	**178.130** 7.013	**2** 0.079	**122.800** 4.8346	**174.800** 6.8819	14	**26 x 26** 1.0236 x 1.0236	**269000** 60400	**305000** 68500
321	**105** 4.1339	**225** 8.8583	**49** 1.9291	**121.260** 4.774	**208.737** 8.218	**2.5** 0.098	**130.799** 5.1496	**202.799** 7.9842	12	**36 x 36** 1.4173 x 1.4173	**438000** 98500	**480000** 108000
421	**105** 4.1339	**260** 10.2362	**60** 2.3622	**127.762** 5.030	**237.236** 9.340	**3** 0.118	**145.500** 5.7284	**219.500** 8.6418	12	**37 x 37** 1.4567 x 1.4567	**464000** 104000	**517000** 116000
022	**110** 4.3307	**150** 5.9055	**20** 0.7874	**115.926** 4.564	**144.069** 5.672	**1** 0.039	**118.000** 4.6457	**142.000** 5.5905	26	**12 x 12** 0.4724 x 0.4724	**95500** 21500	**132000** 29800
122	**110** 4.3307	**170** 6.6929	**28** 1.1024	**120.091** 4.728	**159.918** 6.296	**2** 0.079	**121.000** 4.7638	**159.000** 6.2598	18	**19 x 19** 0.7480 x 0.7480	**179000** 40200	**219000** 49300
222	**110** 4.3307	**200** 7.8740	**38** 1.4961	**122.199** 4.811	**187.782** 7.393	**2** 0.079	**127.000** 5.0000	**183.000** 7.2047	14	**28 x 28** 1.1024 x 1.1024	**311000** 69800	**354000** 79600
322	**110** 4.3307	**240** 9.4480	**50** 1.9685	**127.102** 5.004	**222.885** 8.775	**2.5** 0.098	**138.900** 5.4685	**214.900** 8.4606	12	**38 x 38** 1.4961 x 1.4961	**487000** 109000	**539000** 121000
422	**110** 4.3307	**280** 11.0236	**65** 2.5591	**132.740** 5.226	**257.251** 10.128	**3** 0.118	**155.000** 6.1024	**235.000** 9.2520	12	**40 x 40** 1.5748 x 1.5748	**539000** 121000	**608000** 137000
024	**120** 4.7244	**165** 6.4961	**22** 0.8661	**126.162** 4.967	**158.852** 6.254	**1** 0.039	**129.200** 5.0866	**157.200** 6.1890	26	**14 x 14** 0.5512 x 0.5512	**130000** 29300	**182000** 41000
124	**120** 4.7244	**180** 7.0866	**28** 1.1024	**130.124** 5.123	**169.875** 6.688	**2** 0.079	**131.950** 5.1949	**169.950** 6.6909	20	**19 x 19** 0.7480 x 0.7480	**192000** 43200	**247000** 55400
224	**120** 4.7244	**215** 8.4646	**40** 1.5748	**132.105** 5.201	**202.895** 7.988	**2** 0.079	**138.999** 5.4724	**198.999** 7.8346	14	**30 x 30** 1.1811 x 1.1811	**355000** 79800	**411000** 92400
324	**120** 4.7244	**260** 10.2362	**55** 2.1654	**138.379** 5.448	**241.630** 9.513	**2.5** 0.098	**150.099** 5.9094	**234.099** 9.2165	12	**42 x 42** 1.6535 x 1.6535	**590000** 133000	**662000** 149000
424	**120** 4.7244	**310** 12.2047	**72** 2.8346	**154.940** 6.100	**275.057** 10.829	**4** 0.157	**170.000** 6.6929	**260.000** 10.2362	12	**45 x 45** 1.7717 x 1.7717	**676000** 152000	**774000** 174000

R = maximum shaft or housing fillet radius that bearing corner will clear.
C_r = ANSI/ABMA dynamic radial load rating (33⅓ RPM for 500 hours and 90 percent survival, equivalent to 1000000 inner ring revolutions).
C_{or} = ANSI/ABMA static radial load rating.

Timken Size Code	Boundary Dimensions										Load Ratings	
	d	D	W	Mounting Shoulder Diameter		R	Nominal Roller Path Diameter		Roller		C_r	C_{or}
	Bore	Outside Diameter	Width	A	S	Radius	Inner	Outer	No.	Diameter x Length	Dynamic Radial Capacity	Static Radial Capacity
				Min. Shaft	Max. Housing							
	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.		mm in.	Newtons lbs.	Newtons lbs.
026	**130** 5.1181	**180** 7.0866	**24** 0.9449	**138.430** 5.450	**171.552** 6.754	**1.5** 0.059	**140.000** 5.5118	**170.000** 6.6929	26	**15 x 15** 0.5906 x 0.5906	**148000** 33400	**211000** 47500
126	**130** 5.1181	**200** 7.8740	**33** 1.2992	**140.564** 5.534	**189.433** 7.458	**2** 0.079	**145.000** 5.7087	**185.000** 7.2835	20	**20 x 20** 0.7874 x 0.7874	**212000** 47600	**276000** 62100
226	**130** 5.1181	**230** 9.0551	**40** 1.5748	**144.704** 5.697	**215.290** 8.476	**2.5** 0.098	**151.501** 5.9646	**211.501** 8.3268	16	**30 x 30** 1.1811 x 1.1811	**392000** 88000	**477000** 107000
326	**130** 5.1181	**280** 11.0236	**58** 2.2835	**150.800** 5.937	**259.182** 10.204	**3** 0.118	**162.250** 6.3878	**252.250** 9.9311	12	**45 x 45** 1.7717 x 1.7717	**674000** 152000	**766000** 172000
426	**130** 5.1181	**340** 13.3858	**78** 3.0709	**164.948** 6.494	**305.054** 12.010	**4** 0.157	**186.000** 7.3229	**284.000** 11.1811	12	**49 x 49** 1.9291 x 1.9291	**796000** 179000	**925000** 208000
028	**140** 5.5118	**190** 7.4803	**24** 0.9449	**148.438** 5.844	**181.559** 7.148	**1.5** 0.059	**150.000** 5.9055	**180.000** 7.0866	28	**15 x 15** 0.5906 x 0.5906	**155000** 34900	**229000** 51500
128	**140** 5.5118	**210** 8.2677	**33** 1.2992	**150.647** 5.931	**199.365** 7.849	**2** 0.079	**155.000** 6.1024	**195.000** 7.6772	22	**20 x 20** 0.7874 x 0.7874	**225000** 50700	**306000** 68900
228	**140** 5.5118	**250** 9.8425	**42** 1.6535	**155.931** 6.139	**234.061** 9.215	**2.5** 0.098	**163.000** 6.4173	**227.000** 8.9370	16	**32 x 32** 1.2598 x 1.2598	**443000** 99700	**547000** 123000
328	**140** 5.5118	**300** 11.8110	**62** 2.4409	**161.366** 6.353	**278.638** 10.970	**3** 0.118	**172.499** 6.7913	**272.499** 10.7283	10	**50 x 50** 1.9685 x 1.9685	**717000** 161000	**788000** 177000
428	**140** 5.5118	**360** 14.1732	**82** 3.2283	**174.930** 6.887	**325.069** 12.798	**4** 0.157	**199.000** 7.8346	**301.000** 11.8504	12	**51 x 51** 2.0079 x 2.0079	**860000** 193000	**1010000** 227000
030	**150** 5.9055	**210** 8.2677	**28** 1.1024	**159.944** 6.297	**200.050** 7.876	**2** 0.079	**163.000** 6.4173	**197.000** 7.7559	28	**17 x 17** 0.6693 x 0.6693	**191000** 43000	**282000** 63400
130	**150** 5.9055	**225** 8.8583	**35** 1.3780	**161.519** 6.359	**213.487** 8.405	**2** 0.079	**167.005** 6.5750	**211.005** 8.3072	22	**22 x 22** 0.8661 x 0.8661	**272000** 61100	**374000** 84000
230	**150** 5.9055	**270** 10.6299	**45** 1.7717	**166.649** 6.561	**253.340** 9.974	**2.5** 0.098	**174.000** 6.8504	**246.000** 9.6850	14	**36 x 36** 1.4173 x 1.4173	**494000** 111000	**591000** 133000
032	**160** 6.2992	**220** 8.6614	**28** 1.1024	**169.875** 6.688	**210.134** 8.273	**2** 0.079	**172.000** 6.7716	**208.000** 8.1890	28	**18 x 18** 0.7087 x 0.7087	**214000** 48100	**319000** 71600
132	**160** 6.2992	**240** 9.4488	**38** 1.4961	**172.110** 6.776	**227.889** 8.972	**2** 0.079	**176.000** 6.9291	**224.000** 8.8189	22	**24 x 24** 0.9449 x 0.9449	**323000** 72700	**447000** 101000
232	**160** 6.2992	**290** 11.4173	**48** 1.8898	**177.470** 6.987	**272.542** 10.730	**2.5** 0.098	**189.000** 7.4409	**261.000** 10.2756	16	**36 x 36** 1.4173 x 1.4173	**545000** 122000	**685000** 154000
034	**170** 6.6929	**230** 9.0551	**28** 1.1024	**179.908** 7.083	**220.091** 8.665	**2** 0.079	**182.900** 7.2008	**218.900** 8.6181	28	**18 x 18** 0.7087 x 0.7087	**212000** 47700	**320000** 72000
134	**170** 6.6929	**260** 10.2362	**42** 1.6535	**182.677** 7.192	**247.320** 9.737	**2** 0.079	**189.000** 7.4409	**241.000** 9.4882	22	**26 x 26** 1.0236 x 1.0236	**367000** 82600	**510000** 115000
036	**180** 7.0866	**250** 9.8425	**33** 1.2992	**190.475** 7.499	**239.522** 9.430	**2** 0.079	**195.000** 7.6771	**235.000** 9.2519	28	**20 x 20** 0.7874 x 0.7874	**262000** 58900	**399000** 89800
136	**180** 7.0866	**280** 11.0236	**46** 1.8110	**192.634** 7.584	**267.360** 10.526	**2** 0.079	**200.000** 7.8740	**260.000** 10.2362	20	**30 x 30** 1.1811 x 1.1811	**455000** 102000	**621000** 140000
038	**190** 7.4803	**260** 10.2362	**33** 1.2992	**200.406** 7.890	**249.580** 9.826	**2** 0.079	**205.000** 8.0709	**245.000** 9.6456	28	**20 x 20** 0.7874 x 0.7874	**260000** 58500	**401000** 90200
138	**190** 7.4803	**290** 11.4173	**46** 1.8110	**202.895** 7.988	**277.114** 10.910	**2** 0.079	**208.000** 8.1890	**272.000** 10.7086	20	**32 x 32** 1.2598 x 1.2598	**517000** 116000	**709000** 159000
040	**200** 7.8740	**280** 11.0236	**38** 1.4961	**211.887** 8.342	**268.097** 10.555	**2** 0.079	**216.000** 8.5039	**264.000** 10.3937	26	**24 x 24** 0.9449 x 0.9449	**357000** 80300	**540000** 121000
044	**220** 8.6614	**300** 11.8110	**38** 1.4961	**231.800** 9.126	**288.188** 11.346	**2** 0.079	**236.000** 9.2913	**284.000** 11.1811	28	**24 x 24** 0.9449 x 0.9449	**372000** 83700	**587000** 132000

R = maximum shaft or housing fillet radius that bearing corner will clear.
C_r = ANSI/ABMA dynamic radial load rating (33⅓ RPM for 500 hours and 90 percent survival, equivalent to 1000000 inner ring revolutions).
C_{or} = ANSI/ABMA static radial load rating.

BALL BEARINGS

BASIC CONSTRUCTION TYPES

Any of four basic ball bearing constructions in sizes ranging from 10 mm bore to 600 mm (0.3937 in. to 23.6220 in.) O.D. can be manufactured to meet the most demanding performance requirements.

Selection of the bearing construction best suited to the application must consider the relative importance of the various design functions as listed on page 12. The following general descriptions of each type will further assist in the proper selection.

HK Type

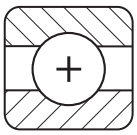

Fig. 5. Deep-groove (Conrad) design.

The conventional deep-groove (Conrad) bearing's versatile load capability allows it to handle radial, axial, moment, reversible axial or combination load ng conditions Cages – either a two-piece (riveted or welded) design or a one-piece, open-face crown design – while not having the ultimate strength and speed capability of a one-piece solid design – perform well in most applications. Where speeds and loads are severe, Timken Aerospace has developed high-strength deep-groove cage options. Seals and/or shields are readily adaptable to this series, particularly with high-strength, non-metallic molded crown cages.

HA Type HJ Type

Fig. 6. Angular contact.

Conventional non-separable angular contact bearings with counterbored rings and one-piece, high-strength cages are used in preloaded and/or axially loaded applications. HJ type is especially suited to ult a-high speed applicat ons. Two contact angle ranges are normally specified: 15 degree nominal for lightly preloaded radial applications; 25 degree nominal for heavy preloads and high external axial loads. Angular contact bearings may be supplied as duplex, triplex, etc., sets, which can be accurately preloaded to any specific level and with contact angles that can deviate from those normally specified.

HD Type

Fig. 7. Deep-groove fractured race.

The fractured outer ring design allows a maximum ball complement in a radial deep-groove bearing. This provides up to 56 percent greater dynamic load capacity and 280 percent longer design life over standa d deep-groove types. One-piece, high-strength cages allow for higher speeds and loads while reducing the chance of cage damage. While HD bearings are used primarily for radial loads, high-strength 17-4PH stainless holding bands, pressed on ground shoulders, retain the fracture under moderate axial load at 1.0 speed limit dN 10^6. Normal mounting procedures are used, except under severe axial loading or misalignment. Several stacked holding bands can be used to increase the holding power for loose-fit housings. In this case, observe special precaution to avoid displacement or opening of the fracture. Extensive experience has proven there is no advanced tendency to fatigue at the fracture under normal operation with a properly retained outer ring.

HT Type

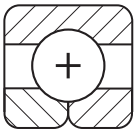

Fig. 8. Two-piece inner ring.

High-performance two piece inner r ng bearings are typically used on high-speed shafts with reversing axial loads. Full deep-groove outer ring, one-piece high-strength cage and two extra-deep-groove inner ring halves provide the maximum level of reliability with full axial capacity in either direction. Simultaneous race grinding assures matching between the two inner ring halves, and a controlled offset may be specified to reduce endplay. The HT series can be readily disassembled for inspection of the race and ball components. Ball-retaining cages or a removable retaining clip – designed to hold inner halves together during normal handling – also are used. Operating contact angles are usually set between 25 degrees and 35 degrees, but develop final selections of detailed characteristics with your Timken engineer.

CAGE OPTIONS

Following the selection of the basic bearing construction, choosing the proper cage and ball complement results in the optimum bearing for the application. The ball bearing cage is critical to bearing performance. While its primary purpose is to separate the balls in the bearing assembly, it must be evaluated for each application as to:

- Performance at various speed levels.
- Compatibility with environmental conditions.
- Compatibility with lubricant systems.
- Cost and availability.

The tables below summarize cage options for metric ball bearings.

Cage Code	Material and Type	Design	Temp. Limit	Speed Limit $dN\ 10^6$	Description
R	Laminated cotton phenolic; one-piece crown snap in		135° C 275° F	0.4	Specified for use with oil impregnation or where a lightweight, land-riding cage is required.
T	Stamped low-carbon steel; two-piece riveted		230° C 450° F	0.5	Use for low-speed, low-temperature accessory applications.
U	Phosphor bronze; stamped two-piece riveted; land piloted; with shaped pockets		190° C 375° F	1.0	Allows rapid acceleration with minimum inertia and maximum exposure to oil flow. Tooling available for limited number of sizes.
B	Precision-machined brass; two-piece riveted		190° C 375° F	1.0	Use for high speeds in aircraft accessories.
Z	AMS 4616 silicon-iron bronze; machined, two-piece riveted		260° C 500° F	1.5	Similar to brass with better strength and wear resistance. Frequently used in combination with VIM-VAR M-50 rings where temperatures exceed the 177° C (350° F) limit for 52100 steel.
H	Machined and hardened AMS 6414 or 6415 alloy steel; silver-plated; two-piece riveted		480° C 900° F	2.0	Use for ultra-high speeds in aircraft accessories. Silver-plating improves wear resistance under marginal lubrication. Normally used with M-50 rings and balls.

Table 5. Deep-groove bearing cage options. Deep-groove cages are two-piece or open-face crown designs.

SPECIAL CAGE OPTIONS

Conrad-design bearings utilizing precision machined cages can be provided with stepped interfaces and detents to meet the needs of applications that experience extreme operating conditions.

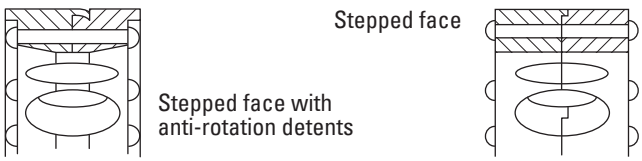

Fig.9. Special cage options.

MAXIMUM CAPACITY CAGE OPTIONS

With the exception of the special full ball complement or stamped-steel cage design, all cages for maximum-capacity ball bearings are one-piece machined designed for maximum strength and balance. They are normally designed to pilot on the outer land to optimize oil-jet lubrication of the inner ring. Outer-land piloting cages provide a self-balancing effect, since any wear improves balance.

Cage Code	Material and Type	Design	Temp. Limit	Speed Limit dN 10^6	Description
F	Full ball complement		Same as bearing material	0.3	Use primarily at low speeds under high radial loads. Provides the maximum possible static and dynamic load capacity. Also use to reduce cost where a cage is not required. Should not be used under heavy combined or misaligned loads with continuous rotation, since the differential ball speeds will cause ball-to-ball scrubbing and a substantial reduction in life.
R	Laminated cotton machined phenolic; one-piece		135° C 275° F	1.0	Use on lightly loaded grease or oil-mist lubricated applications. May be vacuum impregnated to enhance life in “one shot” oiled or greased applications.
B	Precision-machined brass; drilled; one-piece		190° C 375° F	1.5	Use in heavily loaded transmission and accessory applications. Excellent strength and wear performance.
Z	AMS 4616 silicon-iron-bronze; machined; one-piece		260° C 500° F	2.0	Similar to brass with better strength and wear-resistance. Frequently used in combination with VIM-VAR M-50 rings where temperatures exceed the 177° C (350° F) limit for 52100 steel.
H	Machined and hardened AMS 6414 or 6415 alloy steel; silver-plated; one-piece		480° C 900° F	3.0	VIM-VAR M-50 bearings with silver-plated steel cages are first choice of the turbine industry for critical performance mainshaft and powertrain bearings. Steel is silver-plated to enhance run-in, wear life and to provide maximum continuity after lubricant loss.

Table 6. Maximum-capacity bearing cage options.

SEALS AND SHIELDS

Deep-groove construction bearings and some angular contact bearings can be supplied with various types of seals or shields. The choice of seal/shield configuration and material depends on the bearing type and specific application conditions. Shields are used when low torque is important or when excessive heat generation is a concern; however, some degree of grease leakage must be tolerable and the environment relatively clean. Seals have better resistance to contamination and less grease loss, but, conversely, increase torque and heat generation. Typically, molded types of closures are of either Buna N or Viton® and cut-washer types of Teflon® or glass-reinforced Teflon. Stamped-metal shields may be either low-carbon or stainless steel.

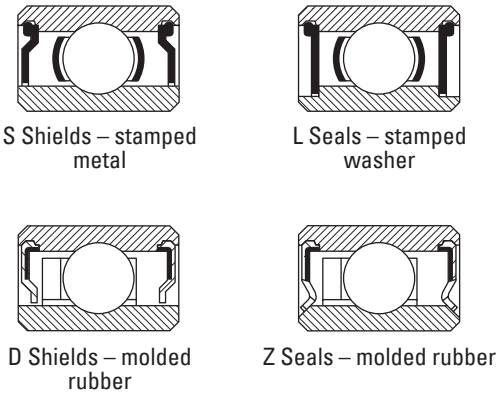

Fig. 10. Seal and shield configurations.

PART NUMBERS, DIMENSIONS AND LOAD RATINGS TABLE

BALL BEARING SPECIFICATIONS

To develop a complete bearing part number:

1) Select MATERIALS AND OPERATING TEMPERATURES prefix (see page 40).
2) Select CONSTRUCTION TYPE, plus CAGE, plus SEAL prefixes.

Cages		HK	HA/HJ	HD	HT
		Deep Groove	Angular Contact	Fractured Ring	Two-Piece Inner Ring
		Construction Types			
Full ball complement	F		HAF, HJF	HDF	HTF
Machined phenolic	R	HKR	HAR, HJR	HDR	HTR
Stamped steel	T	HKT			
Stamped brass	U	HKU			
Machined brass	B	HKB	HAB, HJB	HDB	HTB
Si-Fe bronze	Z	HKZ	HAZ, HJZ	HDZ	HTZ
Silver-plated steel	H	HKH	HAH, HJH	HDH	HTH

Shields and Seals		HK	HK
		One Side	Two Sides
		Construction Types	
Shield - stamped steel	S	HK * S	HK * SS
Shield - molded rubber	D	HK * D	HK * DD
Seal - stamped washer	L	HK * L	HK * LL
Seal - molded rubber	Z	HK * Z	HK * ZZ

* = Cage selection from above

Table 7. Ball bearing specifications.

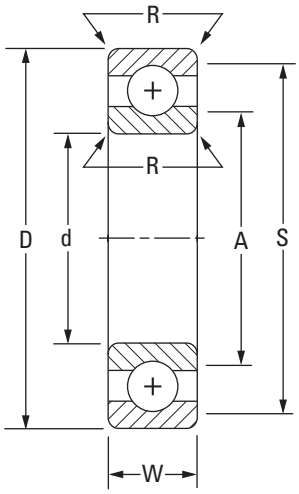

Fig. 11. Ball bearing dimensional features.

3) Select basic bearing TIMKEN SIZE CODE. (See tables on pages 26-30.)
4) Add suffixes for TOLERANCE code (see pages 31-39), RADIAL PLAY code (see pages 41-43), PRELOAD code (see page 44) and LUBRICATION code (see pages 51-53). If any codes are omitted, standard values are applied. For complex assemblies, Timken substitutes a dash number (in lieu of suffixes) to cover all special features.

Examples	3HAH 104 P5(4)DB 10/20	HDB 306-91	26HKTZZ 108-183
Material	3 = 440C stainless steel	Air-melt 52100 steel	CEVM 52100 steel
Construction	HA = angular contact	HD = fractured ring type	HK = deep groove
Cage	H = silver-plated steel	B = machined brass	T = stamped steel
Seals/Shields	(none)	(none)	ZZ = (2) molded-rubber seals
Size	104	306	108
Dash Number	(not used, standard part)	-91 = special features detailed under “dash” 91 code	-183 = special features detailed under “dash” 183 code
Tolerance	Timken P5 = ABEC 5	(not used, dash # part)	(not used, dash # part)
Radial Play	(4) = range 4 clearance	(not used, dash # part)	(not used, dash # part)
Preload	DB10/20 = DB 10 lbs. min to 20 lbs. max	(not used, dash # part)	(not used, dash # part)
Lubrication	No code shown = standard dip	(not used, dash # part)	(not used, dash # part)

Table 8. Ball bearing part number examples.

PART NUMBERS, DIMENSIONS AND LOAD RATINGS TABLE

Timken Size Code	Boundary Dimensions							Load Ratings					
	d	D	W	Mounting Shoulder Diameter		R	Ball Diameter	Max. Capacity Types HA, HD, HT, HJ			CONRAD Type HK		
				A	S				C_r	C_{or}		C_r	C_{or}
	Bore	Outside Diameter	Width	Min. Shaft	Max. Housing	Radius		Balls No. [3]	Dynamic Radial Capacity	Static Radial Capacity	Balls No. [3]	Dynamic Radial Capacity	Static Radial Capacity
	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.		Newtons lbs.	Newtons lbs.		Newtons lbs.	Newtons lbs.
000	**10** 0.3937	**22** 0.8661	**6** 0.2362	**12.014** 0.473	**19.964** 0.786	**0.3** 0.012	**3.572** 9/64	11	**3790** 852	**1900** 427	8	**3060** 688	**1370** 307
100	**10** 0.3937	**26** 1.0236	**8** 0.3150	**12.421** 0.489	**23.571** [1] 0.928 [1]	**0.3** 0.012	**4.763** 3/16	10	**5850** 1310	**2860** 644	7	**4580** 1030	**1970** 443
200	**10** 0.3937	**30** 1.1811	**9** 0.3543	**14.021** 0.552	**25.984** 1.023	**0.6** 0.024	**6.350** 1/4	9	**8690** 1950	**4150** 933	6	**6550** 1470	**2720** 612
300	**10** 0.3937	**35** 1.3780	**11** 0.4331	**14.453** 0.569	**30.556** 1.203	**0.6** 0.024	**7.144** 9/32	9	**10900** 2440	**5350** 1200	6	**8100** 1820	**3440** 774
001	**12** 0.4724	**24** 0.9449	**6** 0.2362	**14.021** 0.552	**21.996** 0.866	**0.3** 0.012	**3.572** 9/64	13	**4260** 959	**2350** 528	9	**3330** 749	**1610** 362
101	**12** 0.4724	**28** 1.1024	**8** 0.3150	**14.326** 0.564	**25.679** 1.011	**0.3** 0.012	**4.763** 3/16	11	**6310** 1420	**3260** 734	8	**5140** 1160	**2440** 549
201	**12** 0.4724	**32** 1.2598	**10** 0.3937	**15.697** 0.618	**28.296** 1.114	**0.6** 0.024	**5.953** 15/64	10	**8690** 1950	**4410** 991	7	**6900** 1550	**3150** 708
301	**12** 0.4724	**37** 1.4567	**12** 0.4724	**17.043** 0.671	**32.029** 1.261	**1** 0.039	**7.938** 5/16	8	**11800** 2660	**5650** 1270	6	**9710** 2180	**4190** 941
002	**15** 0.5906	**28** 1.1024	**7** 0.2756	**17.043** 0.671	**25.959** 1.022	**0.3** 0.012	**3.969** 5/32	14	**5410** 1220	**3170** 712	10	**4320** 972	**2250** 506
102	**15** 0.5906	**32** 1.2598	**9** 0.3543	**17.424** 0.686	**29.591** [1] 1.165 [1]	**0.3** 0.012	**5.556** 7/32	11	**8320** 1870	**4440** 997	8	**6730** 1510	**3220** 725
202	**15** 0.5906	**35** 1.3780	**11** 0.4331	**18.542** 0.730	**31.471** 1.239	**0.6** 0.024	**5.953** 15/64	11	**9430** 2120	**5090** 1140	8	**7620** 1710	**3690** 830
302	**15** 0.5906	**42** 1.6535	**13** 0.5118	**20.218** 0.796	**36.906** 1.453	**1** 0.039	**8.731** 11/32	9	**15500** 3500	**7950** 1790	6	**11800** 2650	**5240** 1180
003	**17** 0.6693	**30** 1.1811	**7** 0.2756	**19.025** 0.749	**27.991** 1.102	**0.3** 0.012	**3.969** 5/32	15	**5650** 1270	**3470** 781	11	**4600** 1030	**2550** 573
103	**17** 0.6693	**35** 1.3780	**10** 0.3937	**19.380** 0.763	**32.614** [2] 1.284 [2]	**0.3** 0.012	**5.556** 7/32	12	**8920** 2010	**5060** 1140	8	**6810** 1530	**3360** 756
203	**17** 0.6693	**40** 1.5748	**12** 0.4724	**20.701** 0.815	**36.297** 1.429	**0.6** 0.024	**7.144** 9/32	10	**12200** 2740	**6520** 1470	8	**10500** 2360	**5210** 1170
303	**17** 0.6693	**47** 1.8504	**14** 0.5512	**22.327** 0.879	**41.681** 1.641	**1** 0.039	**9.525** 3/8	9	**18300** 4120	**9550** 2150	6	**13900** 3130	**6340** 1430
403	**17** 0.6693	**62** 2.4409	**17** 0.6693	**27.635** 1.088	**51.359** 2.022	**1** 0.039	**12.700** 1/2	8	**27500** 6180	**14400** 3230	6	**22700** 5100	**10800** 2430
004	**20** 0.7874	**37** 1.4567	**9** 0.3543	**22.200** 0.874	**34.798** [1] 1.370 [1]	**0.3** 0.012	**4.763** 3/16	16	**8180** 1840	**5390** 1210	11	**6380** 1430	**3680** 827
104	**20** 0.7874	**42** 1.6535	**12** 0.4724	**23.546** 0.927	**38.456** [1] 1.514 [1]	**0.6** 0.024	**6.350** 1/4	13	**12000** 2690	**7240** 1630	9	**9380** 2110	**5030** 1130
204	**20** 0.7874	**47** 1.8504	**14** 0.5512	**24.689** 0.972	**42.291** 1.665	**1** 0.039	**7.938** 5/16	11	**15800** 3550	**9040** 2030	8	**12800** 2880	**6580** 1480
304	**20** 0.7874	**52** 2.0472	**15** 0.5906	**25.197** 0.992	**46.812** 1.843	**1** 0.039	**9.525** 3/8	10	**20300** 4570	**11400** 2560	7	**15900** 3590	**7880** 1770
404	**20** 0.7874	**72** 2.8346	**19** 0.7480	**30.632** 1.206	**61.366** 2.416	**1** 0.039	**14.288** 9/16	7	**31500** 7080	**16300** 3660	6	**28700** 6460	**14100** 3180
005	**25** 0.9843	**42** 1.6535	**9** 0.3543	**27.178** 1.070	**39.827** 1.568	**0.3** 0.012	**4.763** 3/16	19	**9040** 2030	**6630** 1490	13	**7030** 1580	**4520** 1020
105	**25** 0.9843	**47** 1.8504	**12** 0.4724	**28.651** 1.128	**43.332** [1] 1.706 [1]	**0.6** 0.024	**7.144** 9/32	14	**15600** 3500	**10000** 2260	9	**11600** 2610	**6440** 1450
205	**25** 0.9843	**52** 2.0472	**15** 0.5906	**29.616** 1.166	**47.396** 1.866	**1** 0.039	**7.938** 5/16	13	**17900** 4030	**11300** 2540	9	**14000** 3150	**7830** 1760
305	**25** 0.9843	**62** 2.4409	**17** 0.6693	**30.607** 1.205	**56.388** 2.220	**1** 0.039	**11.113** 7/16	11	**28600** 6440	**17200** 3860	7	**21200** 4770	**10900** 2450
405	**25** 0.9843	**80** 3.1496	**21** 0.8268	**37.262** 1.467	**67.742** 2.667	**1.5** 0.059	**16.669** 21/32	8	**45100** 10100	**25000** 5630	6	**37200** 8370	**18700** 4210

[1] Reduce by 0.635 mm (0.025 in.) for fractured race HD bearings.
[2] Reduce by 1.270 mm (0.050 in.) for fractured race HD bearings.
[3] Ball complement is normally one less than the number listed when non-metallic cages or separable HT and HJ bearings with modified cages for ball retention are specified.

R = maximum shaft or housing fillet radius that bearing corner will clear.
C_r = ANSI/ABMA dynamic radial load rating (33⅓ RPM for 500 hours and 90 percent survival, equivalent to 1000000 inner ring revolutions).
C_{or} = ANSI/ABMA static radial load rating.

Timken Size Code	Boundary Dimensions							Load Ratings					
	d	D	W	Mounting Shoulder Diameter		R	Ball Diameter	Max. Capacity Types HA, HD, HT, HJ			CONRAD Type HK		
				A	S			Balls No. [3]	C_r	C_{or}	Balls No. [3]	C_r	C_{or}
	Bore	Outside Diameter	Width	Min. Shaft	Max. Housing	Radius	Ball Diameter		Dynamic Radial Capacity	Static Radial Capacity		Dynamic Radial Capacity	Static Radial Capacity
	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.		Newtons lbs.	Newtons lbs.		Newtons lbs.	Newtons lbs.
006	**30** 1.1811	**47** 1.8504	**9** 0.3543	**32.207** 1.268	**44.806** [2] 1.764 [2]	**0.3** 0.012	**4.763** 3/16	21	**9490** 2130	**7520** 1690	14	**7240** 1630	**5010** 1130
106	**30** 1.1811	**55** 2.1654	**13** 0.5118	**34.544** 1.360	**50.470** 1.987	**1** 0.039	**7.144** 9/32	17	**17700** 3970	**12900** 2890	11	**13200** 2980	**8270** 1860
206	**30** 1.1811	**62** 2.4409	**16** 0.6299	**34.900** 1.374	**57.099** 2.248	**1** 0.039	**9.525** 3/8	13	**24900** 5590	**16300** 3660	9	**19500** 4370	**11300** 2530
306	**30** 1.1811	**72** 2.8346	**19** 0.7480	**35.890** 1.413	**66.091** 2.602	**1** 0.039	**12.700** 1/2	11	**36600** 8220	**22700** 5110	7	**27100** 6090	**14500** 3250
406	**30** 1.1811	**90** 3.5433	**23** 0.9055	**42.240** 1.663	**77.749** 3.061	**1.5** 0.059	**17.463** 11/16	9	**54700** 12300	**32300** 7270	7	**46300** 10400	**25100** 5650
007	**35** 1.3780	**55** 2.1654	**10** 0.3937	**38.354** 1.510	**51.664** [1] 2.034 [1]	**0.6** 0.024	**6.350** 1/4	19	**15200** 3410	**11800** 2650	13	**11800** 2650	**8060** 1810
107	**35** 1.3780	**62** 2.4409	**14** 0.5512	**39.624** 1.560	**57.379** 2.259	**1** 0.039	**7.938** 5/16	17	**21400** 4800	**15900** 3570	11	**16000** 3590	**10300** 2310
207	**35** 1.3780	**72** 2.8346	**17** 0.6693	**40.361** 1.589	**66.624** 2.623	**1** 0.039	**11.906** 15/32	12	**35100** 7890	**23000** 5160	8	**26700** 6010	**15200** 3420
307	**35** 1.3780	**80** 3.1496	**21** 0.8268	**42.748** 1.683	**72.238** 2.844	**1.5** 0.059	**14.288** 9/16	11	**45300** 10200	**28800** 6480	7	**33500** 7530	**18300** 4120
407	**35** 1.3780	**100** 3.9370	**25** 0.9843	**47.244** 1.860	**87.757** 3.455	**1.5** 0.059	**18.256** 23/32	10	**64900** 14600	**41000** 9220	7	**51200** 11500	**28700** 6440
008	**40** 1.5748	**62** 2.4409	**12** 0.4724	**43.358** 1.707	**58.649** [1] 2.309 [1]	**0.6** 0.024	**6.350** 1/4	22	**16400** 3690	**14000** 3150	14	**12200** 2740	**8890** 2000
108	**40** 1.5748	**68** 2.6772	**15** 0.5906	**44.577** 1.755	**63.424** 2.497	**1** 0.039	**7.938** 5/16	19	**22800** 5130	**18300** 4110	12	**16800** 3770	**11500** 2590
208	**40** 1.5748	**80** 3.1496	**18** 0.7087	**45.542** 1.793	**74.447** 2.931	**1** 0.039	**11.906** 15/32	15	**41000** 9210	**30000** 6750	9	**29100** 6550	**17900** 4020
308	**40** 1.5748	**90** 3.5433	**23** 0.9055	**48.133** 1.895	**81.864** 3.223	**1.5** 0.059	**15.875** 5/8	12	**58300** 13100	**39400** 8870	7	**48000** 10800	**29300** 6580
408	**40** 1.5748	**110** 4.3307	**27** 1.0630	**55.880** 2.200	**94.107** 3.705	**2** 0.079	**19.844** 25/32	10	**75800** 17000	**48800** 11000	7	**52200** 11700	**30100** 6770
009	**45** 1.7717	**68** 2.6772	**12** 0.4724	**48.590** 1.913	**64.414** [1] 2.536 [1]	**0.6** 0.024	**6.350** 1/4	24	**17100** 3840	**15600** 3500	16	**13100** 2940	**10300** 2330
109	**45** 1.7717	**75** 2.9528	**16** 0.6299	**49.759** 1.959	**70.231** 2.765	**1** 0.039	**8.731** 11/32	20	**27900** 6270	**23400** 5270	12	**19900** 4470	**14000** 3140
209	**45** 1.7717	**85** 3.3465	**19** 0.7480	**50.419** 1.985	**79.578** 3.133	**1** 0.039	**12.700** 1/2	14	**43900** 9880	**31800** 7160	9	**32700** 7360	**20400** 4590
309	**45** 1.7717	**100** 3.9370	**25** 0.9843	**53.001** 2.087	**91.999** 3.622	**1.5** 0.059	**17.463** 11/16	11	**65400** 14700	**43700** 9830	8	**52800** 11900	**31700** 7120
409	**45** 1.7717	**120** 4.7244	**29** 1.1417	**60.884** 2.397	**104.115** 4.099	**2** 0.079	**20.638** 13/16	11	**87600** 19700	**60000** 13500	8	**70900** 15900	**43600** 9800
010	**50** 1.9685	**72** 2.8346	**12** 0.4724	**53.569** 2.109	**68.453** [1] 2.695 [1]	**0.6** 0.024	**6.350** 1/4	26	**17800** 4000	**17100** 3840	17	**13400** 3010	**11200** 2510
110	**50** 1.9685	**80** 3.1496	**16** 0.6299	**54.788** 2.157	**75.209** 2.961	**1** 0.039	**9.525** 3/8	19	**31700** 7120	**26300** 5910	12	**23300** 5240	**16600** 3730
210	**50** 1.9685	**90** 3.5433	**20** 0.7874	**55.372** 2.180	**84.633** 3.332	**1** 0.039	**12.700** 1/2	15	**46000** 10300	**34800** 7820	10	**35100** 7890	**23200** 5210
310	**50** 1.9685	**110** 4.3307	**27** 1.0630	**59.715** 2.351	**100.279** 3.948	**2** 0.079	**19.050** 3/4	11	**76500** 17200	**52200** 11700	8	**61800** 13900	**37800** 8500
410	**50** 1.9685	**130** 5.1181	**31** 1.2205	**71.145** 2.801	**108.864** 4.286	**2** 0.079	**21.431** 27/32	11	**94500** 21200	**65900** 14800	8	**76400** 17200	**47900** 10800
011	**55** 2.1654	**80** 3.1496	**13** 0.5118	**60.071** 2.365	**74.930** 2.950	**1** 0.039	**7.938** 5/16	24	**25800** 5790	**24100** 5430	15	**18900** 4240	**15100** 3390
111	**55** 2.1654	**90** 3.5433	**18** 0.7087	**60.909** 2.398	**84.099** 3.311	**1** 0.039	**11.113** 7/16	18	**40500** 9100	**33600** 7550	12	**30900** 6940	**22400** 5030
211	**55** 2.1654	**100** 3.9370	**21** 0.8268	**62.128** 2.446	**92.888** 3.657	**1.5** 0.059	**14.288** 9/16	15	**56800** 12800	**43900** 9870	10	**43400** 9750	**29200** 6560
311	**55** 2.1654	**120** 4.7244	**29** 1.1417	**64.973** 2.558	**110.033** 4.332	**2** 0.079	**20.638** 13/16	11	**88400** 19900	**61300** 13800	8	**71500** 16100	**44500** 10000
411	**55** 2.1654	**140** 5.5118	**33** 1.2992	**76.149** 2.998	**118.872** 4.680	**2** 0.079	**22.225** 7/8	12	**107000** 24200	**78600** 17700	8	**82000** 18400	**52400** 11800

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R = maximum shaft or housing fillet radius that bearing corner will clear.
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continued on next page

PART NUMBERS, DIMENSIONS AND LOAD RATINGS TABLE continued

Timken Size Code	Boundary Dimensions							Load Ratings					
	d	D	W	Mounting Shoulder Diameter		R	Ball Diameter	Max. Capacity Types HA, HD, HT, HJ			CONRAD Type HK		
				A	S				C_r	C_{or}		C_r	C_{or}
	Bore	Outside Diameter	Width	Min. Shaft	Max. Housing	Radius		Balls No. [3]	Dynamic Radial Capacity	Static Radial Capacity	Balls No. [3]	Dynamic Radial Capacity	Static Radial Capacity
	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.		Newtons lbs.	Newtons lbs.		Newtons lbs.	Newtons lbs.
012	**60** 2.3622	**85** 3.3465	**13** 0.5118	**65.024** 2.560	**79.959** 3.148	**1** 0.039	**7.938** 5/16	25	**26200** 5890	**25400** 5700	16	**19400** 4370	**16200** 3650
112	**60** 2.3622	**95** 3.7402	**18** 0.7087	**65.837** 2.592	**89.154** 3.510	**1** 0.039	**11.113** 7/16	19	**41600** 9360	**36000** 8090	12	**30700** 6890	**22700** 5100
212	**60** 2.3622	**110** 4.3307	**22** 0.8661	**67.259** 2.648	**102.743** 4.045	**1.5** 0.059	**15.875** 5/8	14	**65700** 14800	**50300** 11300	10	**52500** 11800	**35900** 8070
312	**60** 2.3622	**130** 5.1181	**31** 1.2205	**70.231** 2.765	**119.786** 4.716	**2** 0.079	**22.225** 7/8	11	**101000** 22700	**71300** 16000	8	**81800** 18400	**51800** 11600
412	**60** 2.3622	**150** 5.9055	**35** 1.3780	**81.128** 3.194	**128.854** 5.073	**2** 0.079	**23.019** 29/32	12	**115000** 25800	**86000** 19300	8	**87700** 19700	**57300** 12900
013	**65** 2.5591	**90** 3.5433	**13** 0.5118	**69.977** 2.755	**85.014** 3.347	**1** 0.039	**7.938** 5/16	26	**26500** 5950	**26800** 6020	17	**20000** 4490	**17500** 3930
113	**65** 2.5591	**100** 3.9370	**18** 0.7087	**70.790** 2.787	**94.209** 3.709	**1** 0.039	**11.113** 7/16	20	**42800** 9610	**38300** 8610	13	**32100** 7210	**24900** 5590
213	**65** 2.5591	**120** 4.7244	**23** 0.9055	**72.593** 2.858	**112.420** 4.426	**1.5** 0.059	**17.463** 11/16	14	**78000** 17500	**60700** 13600	10	**62300** 14000	**42800** 9630
313	**65** 2.5591	**140** 5.5118	**33** 1.2992	**74.905** 2.949	**130.099** 5.122	**2** 0.079	**23.813** 15/16	12	**121000** 27300	**89500** 20100	8	**92700** 20800	**59600** 13400
413	**65** 2.5591	**160** 6.2992	**37** 1.4587	**86.131** 3.391	**138.862** 5.467	**2** 0.079	**23.813** 15/16	13	**129000** 29000	**101000** 22600	8	**101000** 22700	**69500** 15600
014	**70** 2.7559	**100** 3.9370	**16** 0.6299	**75.260** 2.963	**94.742** 3.730	**1** 0.039	**9.525** 3/8	24	**35400** 7970	**35000** 7870	16	**27100** 6090	**23300** 5240
114	**70** 2.7559	**110** 4.3307	**20** 0.7874	**76.048** 2.994	**103.937** 4.092	**1** 0.039	**12.700** 1/2	19	**52900** 11900	**47100** 10600	13	**41000** 9230	**32200** 7240
214	**70** 2.7559	**125** 4.9213	**24** 0.9449	**77.572** 3.054	**117.424** 4.623	**1.5** 0.059	**17.463** 11/16	15	**81500** 18300	**66000** 14800	10	**62200** 14000	**44000** 9880
314	**70** 2.7559	**150** 5.9055	**35** 1.3780	**81.153** 3.195	**138.836** 5.466	**2** 0.079	**25.400** 1	12	**136000** 30700	**102000** 22900	8	**104000** 23400	**68000** 15300
414	**70** 2.7559	**180** 7.0866	**42** 1.6535	**96.520** 3.800	**153.492** 6.043	**2.5** 0.098	**26.987** 1 1/16	13	**158000** 35500	**129000** 28900	8	**114000** 25700	**79100** 17800
015	**75** 2.9528	**105** 4.1339	**16** 0.6299	**80.289** 3.161	**99.720** 3.926	**1** 0.039	**9.525** 3/8	26	**37000** 8330	**38300** 8600	17	**27900** 6270	**25000** 5620
115	**75** 2.9528	**115** 4.5276	**20** 0.7874	**81.026** 3.190	**108.966** 4.290	**1** 0.039	**12.700** 1/2	20	**54300** 12200	**50100** 11300	13	**40700** 9160	**32500** 7310
215	**75** 2.9528	**130** 5.1181	**25** 0.9843	**82.550** 3.250	**122.428** 4.820	**1.5** 0.059	**26.987** 1 1/16	16	**85000** 19100	**71700** 16100	10	**62100** 14000	**44800** 10100
315	**75** 2.9528	**160** 6.2992	**37** 1.4567	**86.436** 3.403	**148.565** 5.849	**2** 0.079	**26.987** 1 1/16	12	**149000** 33400	**115000** 25900	8	**113000** 25500	**76900** 17300
415	**75** 2.9528	**190** 7.4803	**45** 1.7717	**101.524** 3.997	**163.474** 6.436	**2.5** 0.098	**28.575** 1 1/8	13	**171000** 38400	**144000** 32400	9	**134000** 30100	**99800** 22400
016	**80** 3.1496	**110** 4.3307	**16** 0.6299	**85.242** 3.356	**104.750** 4.124	**1** 0.039	**9.525** 3/8	27	**37500** 8440	**40200** 9030	17	**27600** 6200	**25300** 5680
116	**80** 3.1496	**125** 4.9213	**22** 0.8661	**86.081** 3.389	**118.923** 4.682	**1** 0.039	**14.288** 9/16	19	**65200** 14700	**59800** 13400	13	**50700** 11400	**40900** 9190
216	**80** 3.1496	**140** 5.5118	**26** 1.0236	**89.383** 3.519	**130.607** 5.142	**2** 0.079	**19.050** 3/4	16	**99400** 22300	**85000** 19100	10	**72700** 16300	**53000** 11900
316	**80** 3.1496	**170** 6.6929	**39** 1.5354	**91.719** 3.611	**158.293** 6.232	**2** 0.079	**28.575** 1 1/8	12	**161000** 36200	**130000** 29100	8	**123000** 27600	**86500** 19400
416	**80** 3.1496	**200** 7.8740	**48** 1.8898	**106.528** 4.194	**173.482** 6.830	**2.5** 0.098	**30.162** 1 3/16	13	**184000** 41500	**161000** 36200	9	**144000** 32400	**111000** 25000
017	**85** 3.3465	**120** 4.7244	**18** 0.7087	**90.703** 3.571	**114.300** 4.500	**1** 0.039	**11.113** 7/16	25	**47800** 10700	**49900** 11200	16	**35500** 7990	**31900** 7170
117	**85** 3.3465	**130** 5.1181	**22** 0.8661	**91.262** 3.593	**123.749** 4.872	**1** 0.039	**14.288** 9/16	20	**67100** 15100	**63400** 14300	13	**50300** 11300	**41200** 9270
217	**85** 3.3465	**150** 5.9055	**28** 1.1024	**94.513** 3.721	**140.487** 5.531	**2** 0.079	**20.638** 13/16	15	**110000** 24700	**92800** 20900	10	**84000** 18900	**61800** 13900
317	**85** 3.3465	**180** 7.0866	**41** 1.6142	**98.450** 3.876	**166.802** 6.567	**2.5** 0.098	**28.575** 1 1/8	13	**171000** 38400	**144000** 32400	8	**124000** 27800	**88700** 19900
417	**85** 3.3465	**210** 8.2677	**52** 2.0472	**119.456** 4.703	**175.539** 6.911	**3** 0.118	**31.750** 1 1/4	13	**198000** 44500	**178000** 40100	9	**155000** 34900	**123000** 27700

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Timken Size Code	Boundary Dimensions							Load Ratings					
	d	D	W	Mounting Shoulder Diameter		R	Ball Diameter	Max. Capacity Types HA, HD, HT, HJ			CONRAD Type HK		
				A	S			Balls No. [3]	C_r	C_{or}	Balls No. [3]	C_r	C_{or}
	Bore	Outside Diameter	Width	Min. Shaft	Max. Housing	Radius	Ball Diameter		Dynamic Radial Capacity	Static Radial Capacity		Dynamic Radial Capacity	Static Radial Capacity
	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.		Newtons lbs.	Newtons lbs.		Newtons lbs.	Newtons lbs.
018	**90** 3.5433	**125** 4.9213	**18** 0.7087	**95.682** 3.767	**132.410** 5.213	**1** 0.039	**11.113** 7⁄16	26	**48600** 10900	**52300** 11800	17	**36600** 8240	**34200** 7690
118	**90** 3.5433	**140** 5.5118	**24** 0.9449	**97.587** 3.842	**149.149** 5.872	**1.5** 0.059	**15.875** 5⁄8	20	**81500** 18300	**77800** 17500	13	**61200** 13700	**50500** 11400
218	**90** 3.5433	**160** 6.2992	**30** 1.1811	**100.863** 3.971	**176.251** 6.939	**2** 0.079	**22.225** 7⁄8	15	**126000** 28300	**107000** 24100	10	**96000** 21600	**71400** 16100
318	**90** 3.5433	**190** 7.4803	**43** 1.6929	**103.759** 4.085	**124.282** 4.893	**2.5** 0.098	**30.162** 1 3⁄16	13	**184000** 41500	**161000** 36200	8	**133000** 30000	**98900** 22200
418	**90** 3.5433	**225** 8.8583	**54** 2.1260	**124.460** 4.900	**190.551** 7.502	**3** 0.118	**34.925** 1 3⁄8	12	**214000** 48100	**197000** 44200	8	**163000** 36700	**131000** 29500
019	**95** 3.7402	**130** 5.1181	**18** 0.7087	**100.711** 3.965	**124.282** 4.893	**1** 0.039	**11.113** 7⁄16	28	**50600** 11400	**56700** 12800	18	**37700** 8480	**36400** 8190
119	**95** 3.7402	**145** 5.7087	**24** 0.9449	**102.591** 4.039	**137.414** 5.410	**1.5** 0.059	**15.875** 5⁄8	21	**83700** 18800	**82300** 18500	13	**60800** 13700	**50900** 11400
219	**95** 3.7402	**170** 6.6929	**32** 1.2598	**106.197** 4.181	**158.801** 6.252	**2** 0.079	**23.813** 15⁄16	15	**142000** 32000	**122000** 27500	10	**109000** 24400	**81700** 18400
319	**95** 3.7402	**200** 7.8740	**45** 1.7717	**109.068** 4.294	**185.928** 7.320	**2.5** 0.098	**31.750** 1 1⁄4	13	**198000** 44500	**178000** 40100	8	**143000** 32200	**110000** 24600
419	**95** 3.7402	**240** 9.4488	**55** 2.1654	**129.464** 5.097	**205.537** 8.092	**3** 0.118	**36.513** 1 7⁄16	13	**241000** 54100	**235000** 52800	9	**188000** 42400	**162000** 36500
020	**100** 3.9370	**140** 5.5118	**20** 0.7874	**105.969** 4.172	**134.036** 5.277	**1** 0.039	**12.700** 1⁄2	26	**62200** 14000	**68000** 15300	17	**46800** 10500	**44500** 9990
120	**100** 3.9370	**150** 5.9055	**24** 0.9449	**107.442** 4.230	**142.545** 5.612	**1.5** 0.059	**15.875** 5⁄8	21	**83200** 18700	**83600** 18800	14	**63500** 14300	**55300** 12400
220	**100** 3.9370	**180** 7.0866	**34** 1.3386	**111.531** 4.391	**168.478** 6.633	**2** 0.079	**25.400** 1	15	**160000** 36000	**139000** 31300	10	**122000** 27500	**92600** 20800
320	**100** 3.9370	**215** 8.4646	**47** 1.8504	**115.976** 4.566	**199.009** 7.835	**2.5** 0.098	**34.925** 1 3⁄8	12	**214000** 48200	**197000** 44300	8	**163000** 36700	**131000** 29500
420	**100** 3.9370	**250** 9.8424	**58** 2.2835	**134.468** 5.294	**215.544** 8.486	**3** 0.118	**38.100** 1 1⁄2	13	**255000** 57400	**256000** 57400	9	**200000** 45000	**177000** 39800
021	**105** 4.1339	**145** 5.7087	**20** 0.7874	**110.947** 4.368	**139.040** 5.474	**1** 0.039	**12.700** 1⁄2	27	**63300** 14200	**71200** 16000	17	**46400** 10400	**44800** 10100
121	**105** 4.1339	**160** 6.2992	**26** 1.0236	**114.859** 4.522	**150.139** 5.911	**2** 0.079	**17.463** 11⁄16	21	**99300** 22300	**99600** 22400	13	**72100** 16200	**61700** 13900
221	**105** 4.1339	**190** 7.4803	**36** 1.4173	**116.865** 4.601	**178.130** 7.013	**2** 0.079	**26.987** 1 1⁄16	15	**174000** 39200	**157000** 35200	10	**133000** 29900	**104000** 23500
321	**105** 4.1339	**225** 8.8583	**49** 1.9291	**121.260** 4.774	**208.737** 8.218	**2.5** 0.098	**36.513** 1 7⁄16	12	**228000** 51200	**215000** 48400	8	**174000** 39100	**143000** 32300
421	**105** 4.1339	**260** 10.2362	**60** 2.3622	**139.446** 5.490	**225.527** 8.879	**3** 0.118	**39.688** 1 9⁄16	13	**271000** 60800	**278000** 62400	9	**212000** 47600	**192000** 43200
022	**110** 4.3307	**150** 5.9055	**20** 0.7874	**115.926** 4.564	**144.069** 5.672	**1** 0.039	**12.700** 1⁄2	28	**64300** 14400	**74200** 16700	18	**47800** 10800	**47600** 10700
122	**110** 4.3307	**170** 6.6929	**28** 1.1024	**120.091** 4.728	**159.918** 6.296	**2** 0.079	**19.050** 3⁄4	20	**113000** 25400	**112000** 25300	13	**84700** 19100	**73000** 16400
222	**110** 4.3307	**200** 7.8740	**38** 1.4961	**122.199** 4.811	**187.782** 7.393	**2** 0.079	**28.575** 1 1⁄8	15	**189000** 42400	**176000** 39500	10	**144000** 32400	**117000** 26200
322	**110** 4.3307	**240** 9.4480	**50** 1.9685	**127.102** 5.004	**222.885** 8.775	**2.5** 0.098	**41.275** 1 5⁄8	11	**253000** 57000	**245000** 55100	7	**188000** 42200	**156000** 35100
422	**110** 4.3307	**280** 11.0236	**65** 2.5591	**144.475** 5.688	**245.542** 9.667	**3** 0.118	**42.862** 1 11⁄16	13	**301000** 67700	**322000** 72500	9	**236000** 53000	**223000** 50200
024	**120** 4.7244	**165** 6.4961	**22** 0.8661	**126.162** 4.967	**158.852** 6.254	**1** 0.039	**14.288** 9⁄16	27	**77900** 17500	**90400** 20300	17	**57200** 12900	**56800** 12800
124	**120** 4.7244	**180** 7.0866	**28** 1.1024	**130.124** 5.123	**169.875** 6.688	**2** 0.079	**19.050** 3⁄4	22	**119000** 26800	**125000** 28200	14	**88200** 19800	**79700** 17900
224	**120** 4.7244	**215** 8.4646	**40** 1.5748	**132.105** 5.201	**202.895** 7.988	**2** 0.079	**28.575** 1 1⁄8	16	**197000** 44200	**192000** 43100	10	**144000** 32300	**120000** 26900
324	**120** 4.7244	**260** 10.2362	**55** 2.1654	**138.379** 5.448	**241.630** 9.513	**2.5** 0.098	**44.450** 1 3⁄4	12	**298000** 67100	**311000** 69900	7	**208000** 46800	**181000** 40800
424	**120** 4.7244	**310** 12.2047	**72** 2.8346	**162.408** 6.394	**267.589** 10.535	**4** 0.157	**47.625** 1 7⁄8	13	**349000** 78400	**396000** 89100	9	**273000** 61400	**274000** 61700

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R = maximum shaft or housing fillet radius that bearing corner will clear.
C_r = ANSI/ABMA dynamic radial load rating (33⅓ RPM for 500 hours and 90 percent survival, equivalent to 1000000 inner ring revolutions).
C_{or} = ANSI/ABMA static radial load rating.

continued on next page

PART NUMBERS, DIMENSIONS AND LOAD RATINGS TABLE continued

Timken Size Code	Boundary Dimensions							Load Ratings					
	d	D	W	Mounting Shoulder Diameter		R	Ball Diameter	Max. Capacity Types HA, HD, HT, HJ			CONRAD Type HK		
				A	S				C_r	C_{or}		C_r	C_{or}
	Bore	Outside Diameter	Width	Min. Shaft	Max. Housing	Radius		Balls No. [3]	Dynamic Radial Capacity	Static Radial Capacity	Balls No. [3]	Dynamic Radial Capacity	Static Radial Capacity
	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.		Newtons lbs.	Newtons lbs.		Newtons lbs.	Newtons lbs.
026	**130** 5.1181	**180** 7.0866	**24** 0.9449	**138.430** 5.450	**171.552** 6.754	**1.5** 0.059	**15.875** ⅝	27	**94500** 21300	**111000** 25000	17	**69500** 15600	**69900** 15700
126	**130** 5.1181	**200** 7.8740	**33** 1.2992	**140.564** 5.534	**189.433** 7.458	**2** 0.079	**22.225** ⅞	20	**149000** 33500	**153000** 34400	13	**112000** 25100	**99500** 22400
226	**130** 5.1181	**230** 9.0551	**40** 1.5748	**144.704** 5.697	**215.290** 8.476	**2.5** 0.098	**30.162** 1 3⁄16	17	**220000** 49600	**229000** 51500	11	**165000** 37100	**147000** 33200
326	**130** 5.1181	**280** 11.0236	**58** 2.2835	**150.800** 5.937	**259.182** 10.204	**3** 0.118	**47.625** 1⅞	12	**329000** 73900	**358000** 80500	7	**230000** 51600	**209000** 46900
426	**130** 5.1181	**340** 13.3858	**78** 3.0709	**172.415** 6.788	**297.586** 11.716	**4** 0.157	**52.388** 2 1⁄16	13	**398000** 89500	**478000** 108000	10	**334000** 75200	**368000** 82700
028	**140** 5.5118	**190** 7.4803	**24** 0.9449	**148.438** 5.844	**181.559** 7.148	**1.5** 0.059	**15.875** ⅝	29	**97900** 22000	**120000** 27000	18	**71300** 16000	**74500** 16700
128	**140** 5.5118	**210** 8.2677	**33** 1.2992	**150.647** 5.931	**199.365** 7.849	**2** 0.079	**22.225** ⅞	22	**157000** 35400	**172000** 38600	14	**116000** 26200	**108000** 24400
228	**140** 5.5118	**250** 9.8425	**42** 1.6535	**155.931** 6.139	**234.061** 9.215	**2.5** 0.098	**33.337** 1 5⁄16	16	**244000** 54900	**261000** 58600	10	**178000** 40100	**163000** 36600
328	**140** 5.5118	**300** 11.8110	**62** 2.4409	**161.366** 6.353	**278.638** 10.970	**3** 0.118	**50.800** 2	12	**360000** 81000	**408000** 91800	8	**275000** 61800	**272000** 61100
428	**140** 5.5118	**360** 14.1732	**82** 3.2283	**182.397** 7.181	**317.602** 12.504	**4** 0.157	**55.563** 2 3⁄16	13	**433000** 97200	**539000** 121000	11	**387000** 87000	**456000** 102000
030	**150** 5.9055	**210** 8.2677	**28** 1.1024	**159.944** 6.297	**200.050** 7.876	**2** 0.079	**19.050** ¾	26	**129000** 29000	**153000** 34400	16	**93300** 21000	**94100** 21200
130	**150** 5.9055	**225** 8.8583	**35** 1.3780	**161.519** 6.359	**213.487** 8.405	**2** 0.079	**22.225** ⅞	23	**160000** 36000	**181000** 40700	15	**121000** 27100	**118000** 26500
230	**150** 5.9055	**270** 10.6299	**45** 1.7717	**166.649** 6.561	**253.340** 9.974	**2.5** 0.098	**36.513** 1 7⁄16	16	**277000** 62400	**312000** 70100	10	**203000** 45600	**194000** 43700
032	**160** 6.2992	**220** 8.6614	**28** 1.1024	**169.875** 6.688	**210.134** 8.273	**2** 0.079	**19.050** ¾	27	**131000** 29400	**161000** 36100	17	**96100** 21600	**101000** 22700
132	**160** 6.2992	**240** 9.4488	**38** 1.4961	**172.110** 6.776	**227.889** 8.972	**2** 0.079	**25.400** 1	22	**200000** 45000	**223000** 50100	14	**148000** 33300	**142000** 31800
232	**160** 6.2992	**290** 11.4173	**48** 1.8898	**177.470** 6.987	**272.542** 10.730	**2.5** 0.098	**41.275** 1⅝	15	**316000** 71000	**367000** 82500	9	**225000** 50500	**220000** 49300
034	**170** 6.6929	**230** 9.0551	**28** 1.1024	**179.908** 7.083	**220.091** 8.665	**2** 0.079	**19.050** ¾	29	**136000** 30500	**173000** 38900	18	**98700** 22200	**107000** 24100
134	**170** 6.6929	**260** 10.2362	**42** 1.6535	**182.677** 7.192	**247.320** 9.737	**2** 0.079	**28.575** 1⅛	21	**230000** 51700	**266000** 59900	13	**167000** 37600	**165000** 37100
036	**180** 7.0866	**250** 9.8425	**33** 1.2992	**190.475** 7.499	**239.522** 9.430	**2** 0.079	**22.225** ⅞	27	**174000** 39000	**218000** 48900	17	**128000** 28700	**137000** 30700
136	**180** 7.0866	**280** 11.0236	**46** 1.8110	**192.634** 7.584	**267.360** 10.526	**2** 0.079	**28.575** 1⅛	22	**235000** 52800	**283000** 63700	14	**174000** 39100	**180000** 40500
038	**190** 7.4803	**260** 10.2362	**33** 1.2992	**200.406** 7.890	**249.580** 9.826	**2** 0.079	**22.225** ⅞	28	**176000** 39700	**227000** 51000	17	**126000** 28400	**138000** 31000
138	**190** 7.4803	**290** 11.4173	**46** 1.8110	**202.895** 7.988	**277.114** 10.910	**2** 0.079	**30.162** 1 3⁄16	22	**254000** 57100	**315000** 70700	14	**188000** 42200	**200000** 45000
040	**200** 7.8740	**280** 11.0236	**38** 1.4961	**211.887** 8.342	**268.097** 10.555	**2** 0.079	**25.400** 1	26	**216000** 48700	**272000** 61200	16	**157000** 35200	**167000** 37600
044	**220** 8.6614	**300** 11.8110	**38** 1.4961	**231.800** 9.126	**288.188** 11.346	**2** 0.079	**25.400** 1	28	**224000** 50300	**297000** 66700	18	**167000** 37500	**191000** 42800

[1] Reduce by 0.635 mm (0.025 in.) for fractured race HD bearings.
[2] Reduce by 1.270 mm (0.050 in.) for fractured race HD bearings.
[3] Ball complement is normally one less than the number listed when non-metallic cages or separable HT and HJ bearings with modified cages for ball retention are specified.

R = maximum shaft or housing fillet radius that bearing corner will clear.
C_r = ANSI/ABMA dynamic radial load rating (33⅓ RPM for 500 hours and 90 percent survival, equivalent to 1000000 inner ring revolutions).
C_{or} = ANSI/ABMA static radial load rating.

TOLERANCES

All bearings described in this design guide can be manufactured to ISO "Normal," 6, 5, 4 (ANSI/ABMA 1, 3, 5 or 7) tolerances. Generally, ISO 5 (ANSI/ABMA 5) is the preferred tolerance class for high-reliability aircraft systems. ISO 4 and 2 (ANSI/ABMA classes 7 and 9) may be specified where closer mounting tolerances and runouts are essential for precise position control. Their performance is otherwise similar to ISO 5 (ANSI/ABMA class 5). ISO 4 (ANSI/ABMA class 7) is normally applied only to ball bearings, although roller bearings can be supplied. ISO 2 (ANSI/ABMA class 9)is applicable to ball bearings only.

ISO "Normal" and 6 (ANSI/ABMA 1 and 3) are generally used in industrial and less critical aircraft accessory applications. To facilitate selection, the tolerance charts on the following pages summarize mean bore, outside diameter, width tolerance and maximum radial runout of each ring for all classes. Please refer to ANSI/ABMA Standard 20 for a complete table of all dimensions.

ISO 492 is equivalent to ANSI/ABMA Standard 20.

HOW TO SPECIFY

ANSI/ABMA precision tolerance levels 1 through 9 are indicated in Timken Aerospace part numbers by the suffixes P1, P3, P5 or P9.

INNER RING TOLERANCES

Bore Diameter		Mean Bore Diameter (+0.0000 to minus value below)					Bore Diametral Taper, Max.					Ring Width (+0.0000 to minus value below)			
		ISO and ANSI/ABMA Classes					ISO and ANSI/ABMA Classes					Single Bearing		Preloaded Single Bearing	
												ISO and ANSI/ABMA Classes		ISO and ANSI/ABMA Classes	
Over	Included	Normal	6	5	4	2	Normal	6	5	4	2	Normal, 6	5, 4, 2	Normal, 6	5, 4, 2
		1	3	5	7	9	1	3	5	7	9	1, 3	5, 7, 9	1, 3	5, 7, 9
mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.
2.5	**10**	**0.008**	**0.007**	**0.005**	**0.004**	**0.0025**	**0.006**	**0.005**	**0.003**	**0.002**	**0.0015**	**0.120**	**0.040**	**0.250**	**0.250**
0.0984	0.3937	0.0003	0.0003	0.0002	0.00015	0.0001	0.00025	0.0002	0.0001	0.0001	0.00005	0.0047	0.0016	0.0098	0.0098
10	**18**	**0.008**	**0.007**	**0.005**	**0.004**	**0.0025**	**0.006**	**0.005**	**0.003**	**0.002**	**0.0015**	**0.120**	**0.080**	**0.250**	**0.250**
0.3937	0.7087	0.0003	0.0003	0.0002	0.00015	0.0001	0.00025	0.0002	0.0001	0.0001	0.00005	0.0047	0.0031	0.0098	0.0098
18	**30**	**0.010**	**0.008**	**0.006**	**0.005**	**0.0025**	**0.008**	**0.006**	**0.003**	**0.0025**	**0.0015**	**0.120**	**0.120**	**0.250**	**0.250**
0.7087	1.1811	0.0004	0.0003	0.00025	0.0002	0.0001	0.0003	0.00025	0.0001	0.0001	0.00005	0.0047	0.0047	0.0098	0.0098
30	**50**	**0.012**	**0.010**	**0.008**	**0.006**	**0.0025**	**0.009**	**0.008**	**0.004**	**0.003**	**0.0015**	**0.120**	**0.120**	**0.250**	**0.250**
1.1811	1.9685	0.00045	0.0004	0.0003	0.00025	0.0001	0.00035	0.0003	0.00015	0.0001	0.00005	0.0047	0.0047	0.0098	0.0098
50	**80**	**0.015**	**0.012**	**0.009**	**0.007**	**0.004**	**0.011**	**0.009**	**0.005**	**0.0035**	**0.002**	**0.150**	**0.150**	**0.380**	**0.250**
1.9685	3.1496	0.0006	0.00045	0.00035	0.0003	0.00015	0.00045	0.00035	0.0002	0.00015	0.0001	0.0059	0.0059	0.0150	0.0098
80	**120**	**0.020**	**0.015**	**0.010**	**0.008**	**0.005**	**0.015**	**0.011**	**0.005**	**0.004**	**0.0025**	**0.200**	**0.200**	**0.380**	**0.380**
3.1496	4.7244	0.0008	0.0006	0.0004	0.0003	0.0002	0.0006	0.00045	0.0002	0.00015	0.0001	0.0079	0.0079	0.0150	0.0150
120	**150**	**0.025**	**0.018**	**0.013**	**0.010**	**0.007**	**0.019**	**0.014**	**0.007**	**0.005**	**0.0035**	**0.250**	**0.250**	**0.500**	**0.380**
4.7244	5.9055	0.0010	0.0007	0.0005	0.0004	0.0003	0.00075	0.00055	0.0003	0.0002	0.00015	0.0098	0.0098	0.0197	0.0150
150	**180**	**0.025**	**0.018**	**0.013**	**0.010**	**0.007**	**0.019**	**0.014**	**0.007**	**0.005**	**0.0035**	**0.250**	**0.250**	**0.500**	**0.380**
5.9055	7.0866	0.0010	0.0007	0.0005	0.0004	0.0003	0.00075	0.00055	0.0003	0.0002	0.00015	0.0098	0.0098	0.0197	0.0150
180	**250**	**0.030**	**0.022**	**0.015**	**0.012**	**0.008**	**0.023**	**0.017**	**0.008**	**0.006**	**0.004**	**0.300**	**0.300**	**0.500**	**0.500**
7.0866	9.8425	0.0012	0.00085	0.0006	0.00045	0.0003	0.0009	0.00065	0.0003	0.00025	0.00015	0.0118	0.0118	0.0197	0.0197
250	**315**	**0.035**	**0.025**	**0.018**	-	-	**0.026**	**0.019**	**0.009**	-	-	**0.350**	**0.350**	**0.500**	**0.500**
9.8425	12.4016	0.0014	0.0010	0.0007	-	-	0.0010	0.00075	0.00035	-	-	0.0138	0.0138	0.0197	0.0197
315	**400**	**0.040**	**0.030**	**0.023**	-	-	**0.030**	**0.023**	**0.012**	-	-	**0.400**	**0.040**	**0.630**	**0.630**
12.4016	15.7480	0.0016	0.0012	0.0009	-	-	0.0012	0.0009	0.00045	-	-	0.0157	0.0157	0.0248	0.0248
400	**500**	**0.045**	**0.035**	-	-	-	**0.034**	**0.026**	-	-	-	**0.450**	-	-	-
15.7480	19.6850	0.0018	0.0014	-	-	-	0.0013	0.0010	-	-	-	0.0177	-	-	-
500	**630**	**0.050**	**0.040**	**-**	-	-	**0.038**	**0.030**	-	-	-	**0.500**	-	-	-
19.6850	24.8031	0.0020	0.0016	-	-	-	0.0015	0.0012	-	-	-	0.0197	-	-	-
630	**800**	**0.075**	**-**	**-**	-	-	-	-	-	-	-	**0.750**	-	-	-
24.8031	31.4961	0.0030	**-**	**-**	-	-	-	-	-	-	-	0.0295	-	-	-

Bore Diameter		Bore 2pt Diametral Roundness, Max. 000 (1900) Diameter [1]					Bore 2pt Diametral Roundness, Max. 100 Diameter Series [1]					Bore 2pt Diametral Roundness, Max. 200, 300, 400 Diameter Series [1]				
		ISO and ANSI/ABMA Classes					ISO and ANSI/ABMA Classes					ISO and ANSI/ABMA Classes				
Over	Included	Normal	6	5	4	2	Normal	6	5	4	2	Normal	6	5	4	2
		1	3	5	7	9	1	3	5	7	9	1	3	5	7	9
mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.
2.5	**10**	**0.010**	**0.009**	**0.005**	**0.004**	**0.0025**	**0.008**	**0.007**	**0.004**	**0.003**	**0.0025**	**0.006**	**0.005**	**0.004**	**0.003**	**0.0025**
0.0984	0.3937	0.0004	0.00035	0.0002	0.00015	0.0001	0.0003	0.0003	0.00015	0.0001	0.0001	0.00025	0.0002	0.00015	0.0001	0.0001
10	**18**	**0.010**	**0.009**	**0.005**	**0.004**	**0.0025**	**0.008**	**0.007**	**0.004**	**0.003**	**0.0025**	**0.006**	**0.005**	**0.004**	**0.003**	**0.0025**
0.3937	0.7087	0.0004	0.00035	0.0002	0.00015	0.0001	0.0003	0.0003	0.00015	0.0001	0.0001	0.00025	0.0002	0.00015	0.0001	0.0001
18	**30**	**0.013**	**0.010**	**0.006**	**0.005**	**0.0025**	**0.010**	**0.008**	**0.005**	**0.004**	**0.0025**	**0.008**	**0.006**	**0.005**	**0.004**	**0.0025**
0.7087	1.1811	0.0005	0.0004	0.00025	0.0002	0.0001	0.0004	0.0003	0.0002	0.00015	0.0001	0.0003	0.00025	0.0002	0.00015	0.0001
30	**50**	**0.015**	**0.013**	**0.008**	**0.006**	**0.0025**	**0.012**	**0.010**	**0.006**	**0.005**	**0.0025**	**0.009**	**0.008**	**0.006**	**0.005**	**0.0025**
1.1811	1.9685	0.0006	0.0005	0.0003	0.00025	0.0001	0.00045	0.0004	0.00025	0.0002	0.0001	0.00035	0.0003	0.00025	0.0002	0.0001
50	**80**	**0.019**	**0.015**	**0.009**	**0.007**	**0.004**	**0.019**	**0.015**	**0.007**	**0.005**	**0.004**	**0.011**	**0.009**	**0.007**	**0.005**	**0.004**
1.9685	3.1496	0.00075	0.0006	0.00035	0.0003	0.00015	0.00075	0.0006	0.0003	0.0002	0.00015	0.00045	0.00035	0.0003	0.0002	0.00015
80	**120**	**0.025**	**0.019**	**0.010**	**0.008**	**0.005**	**0.025**	**0.019**	**0.008**	**0.006**	**0.005**	**0.015**	**0.011**	**0.008**	**0.006**	**0.005**
3.1496	4.7244	0.0010	0.00075	0.0004	0.0003	0.0002	0.0010	0.00075	0.0003	0.00025	0.0002	0.0006	0.00045	0.0003	0.00025	0.0002
120	**150**	**0.031**	**0.023**	**0.013**	**0.010**	**0.007**	**0.031**	**0.023**	**0.010**	**0.008**	**0.007**	**0.019**	**0.014**	**0.010**	**0.008**	**0.007**
4.7244	5.9055	0.0012	0.0009	0.0005	0.0004	0.0003	0.0012	0.0009	0.0004	0.0003	0.0003	0.00075	0.00055	0.0004	0.0003	0.0003
150	**180**	**0.031**	**0.023**	**0.013**	**0.010**	**0.007**	**0.031**	**0.023**	**0.010**	**0.008**	**0.007**	**0.019**	**0.014**	**0.010**	**0.008**	**0.007**
5.9055	7.0866	0.0012	0.0009	0.0005	0.0004	0.0003	0.0012	0.0009	0.0004	0.0003	0.0003	0.00075	0.00055	0.0004	0.0003	0.0003
180	**250**	**0.038**	**0.028**	**0.015**	**0.012**	**0.008**	**0.038**	**0.028**	**0.012**	**0.009**	**0.008**	**0.023**	**0.017**	**0.012**	**0.009**	**0.008**
7.0866	9.8425	0.0015	0.0011	0.0006	0.00045	0.0003	0.0015	0.0011	0.00045	0.00035	0.0003	0.0009	0.00065	0.00045	0.00035	0.0003
250	**315**	**0.044**	**0.031**	**0.018**	**-**	**-**	**0.044**	**0.031**	**0.014**	**-**	**-**	**0.026**	**0.019**	**0.014**	**-**	**-**
9.8425	12.4016	0.0017	0.0012	0.0007	-	-	0.0017	0.0012	0.00055	-	-	0.0010	0.00075	0.00055	-	-
315	**400**	**0.050**	**0.038**	**0.023**	**-**	**-**	**0.050**	**0.038**	**0.018**	**-**	**-**	**0.030**	**0.023**	**0.018**	**-**	**-**
12.4016	15.7480	0.0020	0.0015	0.0009	-	-	0.0020	0.0015	0.0007	-	-	0.0012	0.0009	0.0007	-	-
400	**500**	**0.056**	**0.044**	**-**	**-**	**-**	**0.056**	**0.044**	**-**	**-**	**-**	**0.034**	**0.026**	**-**	**-**	**-**
15.7480	19.6850	0.0022	0.0017	-	-	-	0.0022	0.0017	-	-	-	0.0013	0.0010	-	-	-
500	**630**	**0.063**	**0.050**	**-**	**-**	**-**	**0.063**	**0.050**	**-**	**-**	**-**	**0.038**	**0.030**	**-**	**-**	**-**
19.6850	24.8031	0.0025	0.0020	-	-	-	0.0025	0.0020	-	-	-	0.0015	0.0012	-	-	-
630	**800**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
24.8031	31.4961	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[1] For ANSI/ABMA Classes 7 and 9 (ISO 4 and 2), no individual 2point readings outside the limits for mean diameter (pg. 34) are allowed.

INNER RING TOLERANCES continued

Bore Diameter		Radial Runout, Max.					Axial Runout, Max.				
		ISO and ANSI/ABMA Classes					ISO and ANSI/ABMA Classes				
Over	Included	Normal	6	5	4	2	Normal	6	5	4	2
		1	3	5	7	9	1	3	5	7	9
mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.
2.5	**10**	**0.010**	**0.006**	**0.004**	**0.0025**	**0.0015**	**0.020**	**0.015**	**0.007**	**0.003**	**0.0015**
0.0984	0.3937	0.0004	0.00025	0.00015	0.0001	0.00005	0.0008	0.0006	0.0003	0.0001	0.00005
10	**18**	**0.010**	**0.007**	**0.004**	**0.0025**	**0.0015**	**0.020**	**0.020**	**0.007**	**0.003**	**0.0015**
0.3937	0.7087	0.0004	0.0003	0.00015	0.0001	0.00005	0.0008	0.0008	0.0003	0.0001	0.00005
18	**30**	**0.013**	**0.008**	**0.004**	**0.003**	**0.0025**	**0.025**	**0.020**	**0.008**	**0.004**	**0.0025**
0.7087	1.1811	0.0005	0.0003	0.00015	0.0001	0.0001	0.0010	0.0008	0.0003	0.00015	0.0001
30	**50**	**0.015**	**0.010**	**0.005**	**0.004**	**0.0025**	**0.030**	**0.020**	**0.008**	**0.004**	**0.0025**
1.1811	1.9685	0.0006	0.0004	0.0002	0.00015	0.0001	0.0012	0.0008	0.0003	0.00015	0.0001
50	**80**	**0.020**	**0.010**	**0.005**	**0.004**	**0.0025**	**0.030**	**0.025**	**0.008**	**0.005**	**0.0025**
1.9685	3.1496	0.0008	0.0004	0.0002	0.00015	0.0001	0.0012	0.0010	0.0003	0.0002	0.0001
80	**120**	**0.025**	**0.013**	**0.006**	**0.005**	**0.0025**	**0.035**	**0.025**	**0.009**	**0.005**	**0.0025**
3.1496	4.7244	0.0010	0.0005	0.00025	0.0002	0.0001	0.0014	0.0010	0.00035	0.0002	0.0001
120	**150**	**0.030**	**0.018**	**0.008**	**0.006**	**0.0025**	**0.040**	**0.030**	**0.010**	**0.007**	**0.0025**
4.7244	5.9055	0.0012	0.0007	0.0003	0.00025	0.0001	0.0016	0.0012	0.0004	0.0003	0.0001
150	**180**	**0.030**	**0.018**	**0.008**	**0.006**	**0.005**	**0.040**	**0.030**	**0.010**	**0.007**	**0.005**
5.9055	7.0866	0.0012	0.0007	0.0003	0.00025	0.0002	0.0016	0.0012	0.0004	0.0003	0.0002
180	**250**	**0.040**	**0.020**	**0.010**	**0.008**	**0.005**	**0.045**	**0.035**	**0.013**	**0.008**	**0.005**
7.0866	9.8425	0.0016	0.0008	0.0004	0.0003	0.0002	0.0018	0.0014	0.0005	0.0003	0.0002
250	**315**	**0.050**	**0.025**	**0.013**	-	-	**0.055**	**0.040**	**0.015**	-	-
9.8425	12.4016	0.0020	0.0010	0.0005	-	-	0.0022	0.0016	0.0006	-	-
315	**400**	**0.060**	**0.030**	**0.015**	-	-	**0.065**	**0.045**	**0.020**	-	-
12.4016	15.7480	0.0024	0.0012	0.0006	-	-	0.0026	0.0018	0.0008	-	-
400	**500**	**0.065**	**0.035**	-	-	-	**0.075**	**0.050**	-	-	-
15.7480	19.6850	0.0026	0.0014	-	-	-	0.0030	0.0020	-	-	-
500	**630**	**0.070**	**0.040**	-	-	-	**0.090**	**0.055**	-	-	-
19.6850	24.8031	0.0028	0.0016	-	-	-	0.0035	0.0022	-	-	-
630	**800**	**0.080**	-	-	-	-	**0.100**	-	-	-	-
24.8031	31.4961	0.0031	-	-	-	-	0.0039	-	-	-	-

Bore Diameter		Face to Bore Runout, Max.					Face Parallelism, Max.				
		ISO and ANSI/ABMA Classes					ISO and ANSI/ABMA Classes				
Over	Included	Normal	6	5	4	2	Normal	6	5	4	2
		1	3	5	7	9	1	3	5	7	9
mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.
2.5 0.0984	**10** 0.3937	NR	NR	**0.007** 0.0003	**0.003** 0.0001	**0.0015** 0.00005	**0.015** 0.0006	**0.015** 0.0006	**0.005** 0.0002	**0.0025** 0.0001	**0.0015** 0.00005
10 0.3937	**18** 0.7087	NR	NR	**0.007** 0.0003	**0.003** 0.0001	**0.0015** 0.00005	**0.020** 0.0008	**0.020** 0.0008	**0.005** 0.0002	**0.0025** 0.0001	**0.0015** 0.00005
18 0.7087	**30** 1.1811	NR	NR	**0.008** 0.0003	**0.004** 0.00015	**0.0015** 0.00005	**0.020** 0.0008	**0.020** 0.0008	**0.005** 0.0002	**0.0025** 0.0001	**0.0015** 0.00005
30 1.1811	**50** 1.9685	NR	NR	**0.008** 0.0003	**0.004** 0.00015	**0.0015** 0.00005	**0.020** 0.0008	**0.020** 0.0008	**0.005** 0.0002	**0.003** 0.0001	**0.0015** 0.00005
50 1.9685	**80** 3.1496	NR	NR	**0.008** 0.0003	**0.005** 0.0002	**0.0015** 0.00005	**0.025** 0.0010	**0.025** 0.0010	**0.006** 0.00025	**0.004** 0.00015	**0.0015** 0.00005
80 3.1496	**120** 4.7244	NR	NR	**0.009** 0.00035	**0.005** 0.0002	**0.0025** 0.0001	**0.025** 0.0010	**0.025** 0.0010	**0.007** 0.0003	**0.004** 0.00015	**0.0025** 0.0001
120 4.7244	**150** 5.9055	NR	NR	**0.010** 0.0004	**0.006** 0.00025	**0.0025** 0.0001	**0.030** 0.0012	**0.030** 0.0012	**0.008** 0.0003	**0.005** 0.0002	**0.0025** 0.0001
150 5.9055	**180** 7.0866	NR	NR	**0.010** 0.0004	**0.006** 0.00025	**0.004** 0.00015	**0.030** 0.0012	**0.030** 0.0012	**0.008** 0.0003	**0.005** 0.0002	**0.004** 0.00015
180 7.0866	**250** 9.8425	NR	NR	**0.011** 0.00045	**0.007** 0.0003	**0.005** 0.0002	**0.030** 0.0012	**0.030** 0.0012	**0.010** 0.0004	**0.006** 0.00025	**0.005** 0.0002
250 9.8425	**315** 12.4016	NR	NR	**0.013** 0.0005	**-** -	**-** -	**0.035** 0.0014	**0.035** 0.0014	**0.013** 0.0005	**-** -	**-** -
315 12.4016	**400** 15.7480	NR	NR	**0.015** 0.0006	**-** -	**-** -	**0.040** 0.0016	**0.040** 0.0016	**0.015** 0.0006	**-** -	**-** -
400 15.7480	**500** 19.6850	-	-	**-** -	**-** -	**-** -	**0.050** 0.0020	**0.045** 0.0018	**-** -	**-** -	**-** -
500 19.6850	**630** 24.8031	-	-	**-** -	**-** -	**-** -	**0.060** 0.0024	**0.050** 0.0020	**-** -	**-** -	**-** -
630 24.8031	**800** 31.4961	-	-	**-** -	**-** -	**-** -	**0.070** 0.0028	**-** -	**-** -	**-** -	**-** -

NR = no standardized requirement for this feature.

OUTER RING TOLERANCES

Outside Diameter (O.D.)		Mean O.D. Diameter (+0.0000 to minus value below)					O.D. Diametral Taper, Max.					Ring Width (+0.0000 to minus value below)			
		ISO and ANSI/ABMA Classes					ISO and ANSI/ABMA Classes					Single Bearing		Preloaded Single Bearing	
												ISO and ANSI/ABMA Classes		ISO and ANSI/ABMA Classes	
Over	Included	Normal	6	5	4	2	Normal	6	5	4	2	Normal, 6	5, 4, 2	Normal, 6	5, 4, 2
		1	3	5	7	9	1	3	5	7	9	1, 3	5, 7, 9	1, 3	5, 7, 9
mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.
18	**30**	**0.009**	**0.008**	**0.006**	**0.005**	**0.004**	**0.007**	**0.006**	**0.003**	**0.0025**	**0.002**				
0.7087	1.1811	0.00035	0.0003	0.00025	0.0002	0.00015	0.0003	0.00025	0.0001	0.0001	0.0001				
30	**50**	**0.011**	**0.009**	**0.007**	**0.006**	**0.004**	**0.008**	**0.007**	**0.004**	**0.003**	**0.002**				
1.1811	1.9685	0.00045	0.00035	0.0003	0.00025	0.00015	0.0003	0.0003	0.00015	0.0001	0.0001				
50	**80**	**0.013**	**0.011**	**0.009**	**0.007**	**0.004**	**0.010**	**0.008**	**0.005**	**0.0035**	**0.002**				
1.9685	3.1496	0.0005	0.00045	0.00035	0.0003	0.00015	0.0004	0.0003	0.0002	0.00015	0.0001				
80	**120**	**0.015**	**0.013**	**0.010**	**0.008**	**0.005**	**0.011**	**0.010**	**0.005**	**0.004**	**0.0025**				
3.1496	4.7244	0.0006	0.0005	0.0004	0.0003	0.0002	0.00045	0.0004	0.0002	0.00015	0.0001				
120	**150**	**0.018**	**0.015**	**0.011**	**0.009**	**0.005**	**0.014**	**0.011**	**0.006**	**0.005**	**0.0025**				
4.7244	5.9055	0.0007	0.0006	0.00045	0.00035	0.0002	0.00055	0.00045	0.00025	0.0002	0.0001				
150	**180**	**0.025**	**0.018**	**0.013**	**0.010**	**0.007**	**0.019**	**0.014**	**0.007**	**0.005**	**0.0035**				
5.9055	7.0866	0.0010	0.0007	0.0005	0.0004	0.0003	0.00075	0.00055	0.0003	0.0002	0.00015				
180	**250**	**0.030**	**0.020**	**0.015**	**0.011**	**0.008**	**0.023**	**0.015**	**0.008**	**0.006**	**0.004**				
7.0866	9.8425	0.0012	0.0008	0.0006	0.00045	0.0003	0.0009	0.0006	0.0003	0.00025	0.00015				
250	**315**	**0.035**	**0.025**	**0.018**	**0.013**	**0.008**	**0.026**	**0.019**	**0.009**	**0.007**	**0.004**				
9.8425	12.4016	0.0014	0.0010	0.0007	0.0005	0.0003	0.0010	0.00075	0.00035	0.0003	0.00015				
315	**400**	**0.040**	**0.028**	**0.020**	**0.015**	**0.010**	**0.030**	**0.021**	**0.010**	**0.008**	**0.005**				
12.4016	15.7480	0.0016	0.0011	0.0008	0.0006	0.0004	0.0012	0.00085	0.0004	0.0003	0.0002				
400	**500**	**0.045**	**0.033**	**0.023**	-	-	**0.034**	**0.025**	**0.012**	-	-				
15.7480	19.6850	0.0018	0.0013	0.0009	-	-	0.0013	0.0010	0.00045	-	-				
500	**630**	**0.050**	**0.038**	**0.028**	-	-	**0.038**	**0.029**	**0.014**	-	-				
19.6850	24.8032	0.0020	0.0015	0.0011	-	-	0.0015	0.0011	0.00055	-	-				
630	**800**	**0.075**	**0.045**	**0.035**	-	-	**0.055**	**0.034**	**0.018**	-	-				
24.8032	31.4961	0.0030	0.0018	0.0014	-	-	0.0022	0.0013	0.0007	-	-				
800	**1000**	**0.100**	**0.060**	-	-	-	**0.075**	**0.045**	-	-	-				
31.4961	39.3701	0.0039	0.0024	-	-	-	0.0030	0.0018	-	-	-				

Identical to inner ring of same bearing

Outside Diameter (O.D.)		O.D. 2pt Diametral Roundness, Max. 000 (1900) Diameter Series [1]					O.D. 2pt Diametral Roundness, Max. 100 Diameter Series [1]					O.D. 2pt Diametral Roundness, Max. 200, 300, 400 Diameter Series [1]				
		ISO Classes and ANSI/ABMA					ISO Classes and ANSI/ABMA					ISO and ANSI/ABMA Classes				
Over	Included	Normal	6	5	4	2	Normal	6	5	4	2	Normal	6	5	4	2
		1	3	5	7	9	1	3	5	7	9	1	3	5	7	9
mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.
18	**30**	**0.012**	**0.010**	**0.006**	**0.005**	**0.004**	**0.009**	**0.008**	**0.005**	**0.004**	**0.004**	**0.007**	**0.006**	**0.005**	**0.004**	**0.004**
0.7087	1.1811	0.00045	0.0004	0.00025	0.0002	0.00015	0.00035	0.0003	0.0002	0.00015	0.00015	0.0003	0.00025	0.0002	0.00015	0.00015
30	**50**	**0.014**	**0.011**	**0.007**	**0.006**	**0.004**	**0.011**	**0.009**	**0.005**	**0.005**	**0.004**	**0.008**	**0.007**	**0.005**	**.0.005**	**0.004**
1.1811	1.9685	0.00055	0.00045	0.0003	0.00025	0.00015	0.00045	0.00035	0.0002	0.0002	0.00015	0.0003	0.0003	0.0002	0.0002	0.00015
50	**80**	**0.016**	**0.014**	**0.009**	**0.007**	**0.004**	**0.013**	**0.011**	**0.007**	**0.005**	**0.004**	**0.010**	**0.008**	**0.007**	**0.005**	**0.004**
1.9685	3.1496	0.00065	0.00055	0.00035	0.0003	0.00015	0.0005	0.00045	0.0003	0.0002	0.00015	0.0004	0.0003	0.0003	0.0002	0.00015
80	**120**	**0.019**	**0.016**	**0.010**	**0.008**	**0.005**	**0.019**	**0.016**	**0.008**	**0.006**	**0.005**	**0.011**	**0.010**	**0.008**	**0.006**	**0.005**
3.1496	4.7244	0.00075	0.00065	0.0004	0.0003	0.0002	0.00075	0.00065	0.0003	0.00025	0.0002	0.00045	0.0004	0.0003	0.00025	0.0002
120	**150**	**0.023**	**0.019**	**0.011**	**0.009**	**0.005**	**0.023**	**0.019**	**0.008**	**0.007**	**0.005**	**0.0014**	**0.011**	**0.008**	**0.007**	**0.005**
4.7244	5.9055	0.0009	0.00075	0.00045	0.00035	0.0002	0.0009	0.00075	0.0003	0.0003	0.0002	0.00055	0.00045	0.0003	0.0003	0.0002
150	**180**	**0.031**	**0.023**	**0.013**	**0.010**	**0.007**	**0.031**	**0.023**	**0.010**	**0.008**	**0.007**	**0.019**	**0.014**	**0.010**	**0.008**	**0.007**
5.9055	7.0866	0.0012	0.0009	0.0005	0.0004	0.0003	0.0012	0.0009	0.0004	0.0003	0.0003	0.00075	0.00055	0.0004	0.0003	0.0003
180	**250**	**0.038**	**0.025**	**0.015**	**0.011**	**0.008**	**0.038**	**0.025**	**0.011**	**0.008**	**0.008**	**0.023**	**0.015**	**0.011**	**0.008**	**0.008**
7.0866	9.8425	0.0015	0.0010	0.0006	0.00045	0.0003	0.0015	0.0010	0.00045	0.0003	0.0003	0.0009	0.0006	0.00045	0.0003	0.0003
250	**315**	**0.044**	**0.031**	**0.018**	**0.013**	**0.008**	**0.044**	**0.031**	**0.014**	**0.010**	**0.008**	**0.026**	**0.019**	**0.014**	**0.010**	**0.008**
9.8425	12.4016	0.0017	0.0012	0.0007	0.0005	0.0003	0.0017	0.0012	0.00055	0.0004	0.0003	0.0010	0.00075	0.00055	0.0004	0.0003
315	**400**	**0.050**	**0.035**	**0.020**	**0.015**	**0.010**	**0.050**	**0.035**	**0.015**	**0.011**	**0.010**	**0.030**	**0.021**	**0.015**	**0.011**	**0.010**
12.4016	15.7480	0.0020	0.0014	0.0008	0.0006	0.0004	0.0020	0.0014	0.0006	0.00045	0.0004	0.0012	0.00085	0.0006	0.00045	0.0004
400	**500**	**0.056**	**0.041**	**0.023**	**-**	**-**	**0.056**	**0.041**	**0.017**	**-**	**-**	**0.034**	**0.025**	**0.017**	**-**	**-**
15.7480	19.6850	0.0022	0.0016	0.0009	-	-	0.0022	0.0016	0.00065	-	-	0.0013	0.0010	0.00065	-	-
500	**630**	**0.063**	**0.048**	**0.028**	-	-	**0.063**	**0.048**	**0.021**	-	-	**0.038**	**0.029**	**0.021**	-	-
19.6850	24.8032	0.0025	0.0019	0.0011	-	-	0.0025	0.0019	0.00085	-	-	0.0015	0.0011	0.00085	-	-
630	**800**	**0.094**	**0.056**	**0.035**	**-**	**-**	**0.094**	**0.056**	**0.026**	**-**	**-**	**0.055**	**0.034**	**0.026**	**-**	**-**
24.8032	31.4961	0.0037	0.0022	0.0014	-	-	0.0037	0.0022	0.0010	-	-	0.0022	0.0013	0.0010	-	-
800	**1000**	**0.125**	**0.075**	**-**	**-**	**-**	**0.125**	**0.075**	**-**	**-**	**-**	**0.075**	**0.045**	**-**	**-**	**-**
31.4961	39.3701	0.0049	0.0030	-	-	-	0.0049	0.0030	-	-	-	0.0030	0.0018	-	-	-

[1] For ANSI/ABMA Classes 7 and 9 (ISO 4 and 2), no individual 2point readings outside the limits for mean diameter (pg. 38) are allowed.

OUTER RING TOLERANCES continued

Outside Diameter (O.D.)		Radial Runout, Max.					Axial Runout, Max.				
		ISO and ANSI/ABMA Classes					ISO and ANSI/ABMA Classes				
Over	Included	Normal	6	5	4	2	Normal	6	5	4	2
		1	3	5	7	9	1	3	5	7	9
mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.
18 0.7087	**30** 1.1811	**0.015** 0.0006	**0.009** 0.00035	**0.006** 0.00025	**0.004** 0.00015	**0.0025** 0.0001	**0.025** 0.0010	**0.015** 0.0006	**0.008** 0.0003	**0.005** 0.0002	**0.0025** 0.0001
30 1.1811	**50** 1.9685	**0.020** 0.0008	**0.010** 0.0004	**0.007** 0.0003	**0.005** 0.0002	**0.0025** 0.0001	**0.030** 0.0012	**0.020** 0.0008	**0.008** 0.0003	**0.005** 0.0002	**0.0025** 0.0001
50 1.9685	**80** 3.1496	**0.025** 0.0010	**0.013** 0.0005	**0.008** 0.0003	**0.005** 0.0002	**0.004** 0.00015	**0.035** 0.0014	**0.020** 0.0008	**0.010** 0.0004	**0.005** 0.0002	**0.004** 0.00015
80 3.1496	**120** 4.7244	**0.035** 0.0014	**0.018** 0.0007	**0.010** 0.0004	**0.006** 0.00025	**0.005** 0.0002	**0.040** 0.0016	**0.025** 0.0010	**0.011** 0.00045	**0.006** 0.00025	**0.005** 0.0002
120 4.7244	**150** 5.9055	**0.040** 0.0016	**0.020** 0.0008	**0.011** 0.00045	**0.007** 0.0003	**0.005** 0.0002	**0.045** 0.0018	**0.030** 0.0012	**0.013** 0.0005	**0.007** 0.0003	**0.005** 0.0002
150 5.9055	**180** 7.0866	**0.045** 0.0018	**0.023** 0.0009	**0.013** 0.0005	**0.008** 0.0003	**0.005** 0.0002	**0.055** 0.0022	**0.035** 0.0014	**0.014** 0.00055	**0.008** 0.0003	**0.005** 0.0002
180 7.0866	**250** 9.8425	**0.050** 0.0020	**0.025** 0.0010	**0.015** 0.0006	**0.010** 0.0004	**0.007** 0.0003	**0.065** 0.0026	**0.040** 0.0016	**0.015** 0.0006	**0.010** 0.0004	**0.007** 0.0003
250 9.8425	**315** 12.4016	**0.060** 0.0024	**0.030** 0.0012	**0.018** 0.0007	**0.011** 0.00045	**0.007** 0.0003	**0.075** 0.0030	**0.045** 0.0018	**0.018** 0.0007	**0.010** 0.0004	**0.007** 0.0003
315 12.4016	**400** 15.7480	**0.070** 0.0028	**0.035** 0.0014	**0.020** 0.0008	**0.013** 0.0005	**0.008** 0.0003	**0.090** 0.0035	**0.050** 0.0020	**0.020** 0.0008	**0.013** 0.0005	**0.008** 0.0003
400 15.7480	**500** 19.6850	**0.080** 0.0031	**0.040** 0.0016	**0.023** 0.0009	**-** -	**-** -	**0.100** 0.0039	**0.055** 0.0022	**0.023** 0.0009	**-** -	**-** -
500 19.6850	**630** 24.8032	**0.100** 0.0039	**0.050** 0.0020	**0.025** 0.0010	**-** -	**-** -	**0.110** 0.0043	**0.060** 0.0024	**0.025** 0.0010	**-** -	**-** -
630 24.8032	**800** 31.4961	**0.120** 0.0047	**0.060** 0.0024	**0.030** 0.0012	**-** -	**-** -	**0.120** 0.0047	**0.065** 0.0026	**0.030** 0.0012	**-** -	**-** -
800 31.4961	**1000** 39.3701	**0.140** 0.0055	**0.075** 0.0030	**-** -	**-** -	**-** -	**0.125** 0.0049	**0.070** 0.0028	**-** -	**-** -	**-** -

Outside Diameter (O.D.)		O.D. to Face Runout, Max.					Face Parallelism, Max.				
		ISO and ANSI/ABMA Classes					ISO and ANSI/ABMA Classes				
Over	Included	Normal	6	5	4	2	Normal	6	5	4	2
		1	3	5	7	9	1	3	5	7	9
mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.
18 0.7087	**30** 1.1811	NR	NR	**0.008** 0.0003	**0.004** 0.00015	**0.0015** 0.00005			**0.005** 0.0002	**0.0025** 0.0001	**0.0015** 0.00005
30 1.1811	**50** 1.9685	NR	NR	**0.008** 0.0003	**0.004** 0.00015	**0.0015** 0.00005			**0.005** 0.0002	**0.0025** 0.0001	**0.0015** 0.00005
50 1.9685	**80** 3.1496	NR	NR	**0.008** 0.0003	**0.004** 0.00015	**0.0015** 0.00005			**0.006** 0.00025	**0.003** 0.0001	**0.0015** 0.00005
80 3.1496	**120** 4.7244	NR	NR	**0.009** 0.00035	**0.005** 0.0002	**0.0025** 0.0001			**0.008** 0.0003	**0.004** 0.00015	**0.0025** 0.0001
120 4.7244	**150** 5.9055	NR	NR	**0.010** 0.0004	**0.005** 0.0002	**0.0025** 0.0001			**0.008** 0.0003	**0.005** 0.0002	**0.0025** 0.0001
150 5.9055	**180** 7.0886	NR	NR	**0.010** 0.0004	**0.005** 0.0002	**0.0025** 0.0001			**0.008** 0.0003	**0.005** 0.0002	**0.0025** 0.0001
180 7.0866	**250** 9.8425	NR	NR	**0.011** 0.00045	**0.007** 0.0003	**0.004** 0.00015	Identical to inner ring of same bearing		**0.010** 0.0004	**0.007** 0.0003	**0.004** 0.00015
250 9.8425	**315** 12.4016	NR	NR	**0.013** 0.0005	**0.008** 0.0003	**0.005** 0.0002			**0.011** 0.00045	**0.007** 0.0003	**0.005** 0.0002
315 12.4016	**400** 15.7480	NR	NR	**0.013** 0.0005	**0.010** 0.0004	**0.007** 0.0003			**0.013** 0.0005	**0.008** 0.0003	**0.007** 0.0003
400 15.7480	**500** 19.6850	NR	NR	**0.015** 0.0006	- -	- -			**0.015** 0.0006	- -	- -
500 19.6850	**630** 24.8032	NR	NR	**0.018** 0.0007	- -	- -			**0.018** 0.0007	- -	- -
630 24.8032	**800** 31.4961	NR	NR	**0.020** 0.0008	- -	- -			**0.020** 0.0008	- -	- -
800 31.4961	**1000** 39.3701	- -	- -	- -	- -	- -			- -	- -	- -

NR = no standardized requirement for this feature.

NON-DESTRUCTIVE TESTING

In addition to the basic dimensional characteristics defined by ANSI/ABMA Standard 20, many aspects of quality and reliability assurance depend upon the integrity of the manufacturer as well as supplemental tests that are agreed upon in the final specification. Controls on finish, raceway waviness, lobing, roller-path flatness and many other minute variables are carefully defined as a function of tolerance level by Timken. Non-destructive testing techniques are used on a sample basis to help ensure reliability against cracks, material defects and grinding temper marks.

For critical bearings, 100-percent non-destructive testing using fluorescent penetrant, magnetic particle inspection, nital etch testing, Barkhausen noise testing or eddy current testing is available on a contract basis to help ensure reliability of all components.

MATERIALS AND OPERATING TEMPERATURES

STANDARD MATERIAL – HIGH CHROME 52100 BEARING STEEL (AMS 6440)

Unless otherwise indicated, all bearings listed in this design guide are manufactured from vacuum-degassed bearing-quality 52100 steel (AMS 6440). Rings and rolling elements are precision heat-treated to provide the uniform stable structure required for rolling bearings. ANSI/ABMA 3 (ISO class 6) and higher-precision bearings are stabilized typically with special tempers and sub-cooling cycles. This permits operating temperatures ranging from -54 to +177° C (-65° to +350° F) with a hardness of HRC 60 minimum on most standard configurations and HRC 58 minimum on more complex shapes or where higher temperature capability is required. Retained austenite is generally held to less than 4 percent.

SPECIAL MATERIALS

CEVM 52100 (AMS 6444) consumable electrode vacuum remelt improves reliability and fatigue life versus standard 52100. Timken generally recommends that, in an application critical enough to require CEVM 52100, the slight additional cost of VIM-VAR M-50 is more than justified by its many additional benefits.

VIM-VAR 52100 (AMS 6444) vacuum induction melt, followed by a vacuum arc remelt, further improves reliability and fatigue life. Hardness and heat-treatment are similar to other 52100 grades.

VIM-VAR M-50 HIGH-SPEED (AMS 6491)

Vacuum induction melt-vacuum arc remelt (VIM-VAR) M-50 has proven to be the most satisfactory advanced performance material for demanding aircraft engine and accessory applications. VIM-VAR M-50 provides four specific areas of improved performance:

1) M-50 permits operation at or exposure to temperatures up to 427° C (800° F) with dimensional size change controlled within standard limits. Retained austenite is held to 3 percent maximum by the heat-treatment process.
2) M-50 provides extended fatigue life in temperature ranges above 204° C (400° F) common to many aircraft applications. It compensates for application conditions that may cause severe reduction in experienced life, e.g., rapid acceleration, marginal housing or shaft support, differential temperatures, misalignment and other unavoidable conditions.
3) M-50 extends life in "oil out" or marginal lubricant conditions. Under these conditions, surface temperatures immediately rise, causing surface tempering, deformation and seizure. Even after exposure to temperatures as high as 593° C (1100° F), M-50 will not soften significantly (compared to 260° C [500° F] for 52100), providing an extra margin of operable life.
4) M-50 moly-carbides provide greater hardness to reduce fretting and wear under slow-speed or oscillating conditions.

VIM-VAR M-50 NIL (AMS 6278)

A carburized case-hardened variation of M-50, VIM-VAR M-50 NIL (AMS 6278) provides improved fracture toughness due to its softer core. Other properties of conventional M-50, including high-temperature stability and rolling contact fatigue life, are maintained, with the exception of retained austenite, typically 6 percent max. Potential applications include ultra-high-speed (2.4 million dN and above) mainshaft and other applications limited by low fracture toughness.

440C STAINLESS STEEL (AMS 5880)

A 16-percent chromium steel common to miniature and instrument bearings, 440C stainless steel (AMS 5880) also is used in special metric bearings requiring corrosion resistance. Standard tempering and subcooling cycles provide capability for operation at temperatures up to 190° C (375° F). Optional high-temperature draw cycles allow operation at temperatures up to 425° C (800° F); however, this option reduces corrosion resistance. Typical applications include large instrument bearings, reactor control bearings, bearings immersed in jet fuel and lightly loaded high-temperature thrust-reverser controls.

Modified 440C alloys, similar to 440C, contain additional molybdenum to improve hot hardness at high tempering temperatures for applications requiring corrosion and oxidation resistance. In some applications, they provide the best features of both 440C and M-50; however, their high alloy content has led to unpredictable variations in experienced fatigue life. Examples of modified 440C is BG-42® (AMS 5749).

BG-42® (AMS 5749) VIM-VAR

A high-performance Cr-Mo-V alloy, BG-42 (AMS 5749) VIM-VAR is ideal for bearing applications where a hardenable martensitic stainless steel is needed for corrosion resistance, and has hot hardness better than 440C. It performs similarly to M-50, but with added properties described above. Multiple remelting enhances material cleanliness and provides a more reliable performance and fatigue life. It is suitable for use where application temperatures are up to 482° C (900° F).

PYROWEAR 675® (AMS 5930)

A carburizing grade of stainless steel, Pyrowear 675® (AMS 5930) is a corrosion-resistant steel developing a HRC 60 case with a tough ductile core. It has corrosion resistance equivalent to 440C steel.

CERAMIC ROLLING ELEMENTS

Ceramic balls and rollers (silicon nitride) are available for hybrid bearings. This high-performance ceramic has proved beneficial for certain high-temperature, high-corrosive environments. When corrosive environments, exceptionally non-typical bearing temperatures or very high speeds are anticipated in a design, it may be useful to apply a "hybrid" construction. Properly designed ring and cage materials can be mated with ceramic rolling elements – balls or rollers – to obtain the maximum benefits of each. Discuss these special applications with a Timken engineer for guidance.

HOW TO SPECIFY

To select material, choose one of the following as the prefix to the Timken part number:

None – 52100
3 – 440C
5 – VIM-VAR M50
25 – BG-42
26 – CEVM 52100
34 – CEVM 440C
35 – VIM-VAR M50 Nil
58 – Pyrowear 675

RADIAL PLAY AND CONTACT ANGLE

Radial play, or free internal clearance, is one of the most critical bearing design parameters. Contrary to a common misconception, it has nothing to do with quality or ANSI/ABMA or ISO tolerance level. In both ball and roller bearings, radial play is defined as the free radial displacement of the outer ring with respect to a fixed inner ring. In ball bearings, it directly affects and controls the operating contact angle and free axial or endplay. In some ball bearing applications, contact angle or endplay may be the controlling specification. In these cases, radial play is not designated, but is offered as a "reference."

RADIAL PLAY SELECTION – HK, HD AND R TYPES

Ball bearings are normally manufactured to one of the five standard ranges shown in the chart on page 43. Unless otherwise specified, Timken HK (deep-groove) and HD (fractured outer ring) ball bearings and R-series roller bearings are supplied with Group N standard clearances. This standard range has excellent radial stability and load capacity. In ball bearings, Group N provides good resistance to cocking loads and a reasonable degree of axial location without preloading. It also allows for a light press fit on the inner ring for normal rotating shaft applications.

LOOSER FITS

Group 3 and Group 4 clearances may be specified in a bearing for a number of reasons:

1) To allow for a press fit on the outer ring and where necessary on both rings. Keep in mind that 50 percent to 75 percent of an interference fit is reflected in loss of radial play. Temperature extremes cause additional changes in radial play when dissimilar materials are used for shaft and housing materials.
2) To provide higher contact angles under axial loads, thereby reducing stress levels that increase fatigue life, reduce torque and help to improve operating efficiency.
3) To provide greater axial stability, particularly in preloaded bearings.
4) To allow greater static and dynamic misalignment.

TIGHTER FITS

Group 2 clearance may be specified for a bearing slip-fit mounted in both the housing and on the shaft, and operating under straight radial loads. If cocking loads are unavoidable, Group 2 provides the greatest resistance and angular control. If preloading between two bearings is impractical, it also provides the most precise axial location.

RELATIONSHIP BETWEEN RADIAL PLAY, ENDPLAY AND CONTACT ANGLE (HK AND HD SERIES BALL BEARINGS)

The following graph provides the designer with the means to calculate the relationship between radial play, contact angle and endplay for Timken® bearings with standard inner and outer race curvatures. Since curvature significantly affects this relationship, any bearing with inverse curvature or reduced curvature for extra-high load capacity will have a different relationship. The values obtained with this graph are averages and should not be interpreted as acceptance or manufacturing limits.

RADIAL PLAY AND CONTACT ANGLE continued

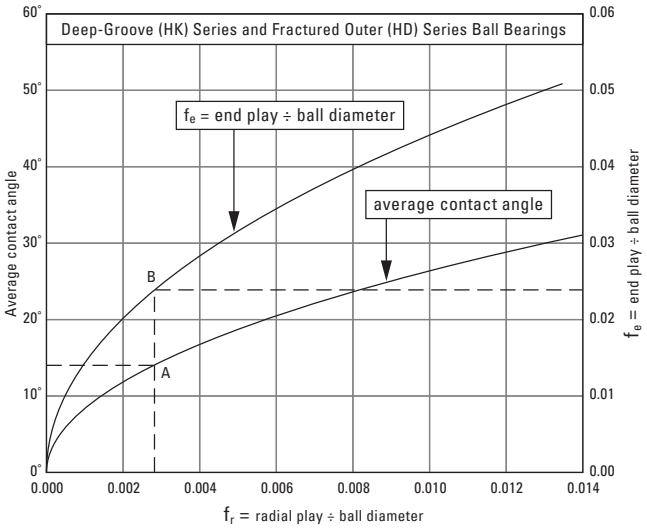


Fig. 12. Relationship between radial play, endplay and contact angle for any ball size.

EXAMPLE:

Determine the average contact angle and the average endplay on an HD 106 bearing with Group 3 (loose) internal clearance:

1) From table of dimensions (see Ball Bearing Specifications page 25) the ball diameter is found to be 9/32 inch (0.28125 inch).
2) From the chart on page 43, the internal clearance for group 3 for a 106 bearing is 0.0005 inch to 0.0011 inch.
3) The conditions for average internal clearance (0.0008 inch) or the extremes (0.0005 inch and 0.0011 inch) may be read off the graph above. First determine the value of f_r.

$$f_r = \frac{\text{radial play}}{\text{ball diameter}} = \frac{0.0008}{0.28125} = 0.00285$$

4) Extend a vertical line from f_r = 0.00285 through curves labeled "Contact Angle" and "f_e" to determine intersection points "A" and "B."
5) Extend horizontal line to left from "A" to determine average contact angle of 14 degrees.
6) To obtain endplay, extend horizontal line to right from point "B" to determine value; f_e = 0.024.
   Solve equation $f_e = \frac{\text{endplay}}{\text{ball diameter}}$

endplay = ball diameter x f_e = 0.28125 x 0.024 = 0.0067 inch

NOTE

An interference fit will reduce the internal clearance by approximately 50 percent to 75 percent of the amount of interference, giving operating conditions of a tighter internal fit-up. If interference fits are used, first determine the reduced internal clearance, then the contact angle or the average endplay of the bearing.

The graph also may be used to determine the required internal clearance range from predetermined axial play or contact angle values.

RADIAL PLAY SELECTION – HA/HJ AND HT TYPES

Angular contact (HA/HJ) ball bearings are normally manufactured to a contact angle tolerance rather than a specified radial play. The two standard contact angles are 15 degrees and 25 degrees; 15 degrees should be used for applications which, while predominantly axially loaded, have a significant radial load component, and 25 degrees should be used for high-axial-load applications.

Split-inner-ring (HT) series bearings are normally manufactured to a contact angle of 25 degrees or higher. Due to the special nature of these bearings, consult your Timken engineer or representative before specifying.

HOW TO SPECIFY:

To specify radial play or contact angle, choose one of the following alternatives and then add the suffix to the basic bearing part number. For standard Group N, the code may be omitted.

1) To specify a radial play range: Select the group code number from table on page 43. Example: "3" indicates Group 3.
2) To specify radial play: Express in ten thousandths (0.0001) of an inch x 10,000. Example: (5/15) indicates 0.0005/0.0015 radial play.
3) To specify contact angle code (HA/HJ-type angular contact bearings only): Use letter code in parentheses. Suffix (D) is equivalent to normal contact angle of 25 degrees.

Codes B and D are standard contact angles offered.

Code	Contact Angle Degrees
A	12
B	15
C	18
D	25
E	30

RADIAL PLAY, BALL BEARINGS

ISO and ANSI/ABMA Radial Play Groups											
Bore Diameter		Group 2		Group N		Group 3		Group 4		Group 5	
≥	≤	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.	mm in.
6 0.2362	10 0.3937	0.000 0.0000	0.007 0.0003	0.002 0.0001	0.013 0.0005	0.008 0.0003	0.023 0.0009	0.014 0.0006	0.029 0.0011	0.020 0.0008	0.037 0.0015
10 0.3937	18 0.7087	0.000 0.0000	0.009 0.00035	0.003 0.0001	0.018 0.0007	0.011 0.00045	0.025 0.0010	0.018 0.0007	0.033 0.0013	0.025 0.0010	0.045 0.0018
18 0.7087	24 0.9449	0.000 0.0000	0.010 0.0004	0.005 0.0002	0.020 0.0008	0.013 0.0005	0.028 0.0011	0.020 0.0008	0.036 0.0014	0.028 0.0011	0.048 0.0019
24 0.9449	30 1.1811	0.001 0.00005	0.011 0.00045	0.005 0.0002	0.020 0.0008	0.013 0.0005	0.028 0.0011	0.023 0.0009	0.041 0.0016	0.030 0.0012	0.053 0.0021
30 1.1811	40 1.5748	0.001 0.00005	0.011 0.00045	0.006 0.00025	0.020 0.0008	0.015 0.0006	0.033 0.0013	0.028 0.0011	0.046 0.0018	0.040 0.0016	0.064 0.0025
40 1.5748	50 1.9685	0.001 0.00005	0.011 0.00045	0.006 0.00025	0.023 0.0009	0.018 0.0007	0.036 0.0014	0.030 0.0012	0.051 0.0020	0.045 0.0018	0.073 0.0029
50 1.9685	65 2.5591	0.001 0.00005	0.015 0.0006	0.008 0.0003	0.028 0.0011	0.023 0.0009	0.043 0.0017	0.038 0.0015	0.061 0.0024	0.055 0.0022	0.090 0.0035
65 2.5591	80 3.1496	0.001 0.00005	0.015 0.0006	0.010 0.0004	0.030 0.0012	0.025 0.0010	0.051 0.0020	0.046 0.0018	0.071 0.0028	0.065 0.0026	0.105 0.0041
80 3.1496	100 3.9370	0.001 0.00005	0.018 0.0007	0.012 0.00045	0.036 0.0014	0.030 0.0012	0.058 0.0023	0.053 0.0021	0.084 0.0033	0.075 0.0030	0.120 0.0047
100 3.9370	120 4.7244	0.002 0.0001	0.020 0.0008	0.015 0.0006	0.041 0.0016	0.036 0.0014	0.066 0.0026	0.061 0.0024	0.097 0.0038	0.090 0.0035	0.140 0.0055
120 4.7244	140 5.5118	0.002 0.0001	0.023 0.0009	0.018 0.0007	0.048 0.0019	0.041 0.0016	0.081 0.0032	0.071 0.0028	0.114 0.0045	0.105 0.0041	0.160 0.0063
140 5.5118	160 6.2992	0.002 0.0001	0.023 0.0009	0.018 0.0007	0.053 0.0021	0.046 0.0018	0.091 0.0036	0.081 0.0032	0.130 0.0051	0.120 0.0047	0.180 0.0071
160 6.2992	180 7.0866	0.002 0.0001	0.025 0.0010	0.020 0.0008	0.061 0.0024	0.053 0.0021	0.102 0.0040	0.091 0.0036	0.147 0.0058	0.135 0.0053	0.200 0.0079
180 7.0886	200 7.8740	0.002 0.0001	0.030 0.0012	0.025 0.0010	0.071 0.0028	0.063 0.0025	0.117 0.0046	0.107 0.0042	0.163 0.0064	0.150 0.0059	0.230 0.0091
200 7.8740	225 8.8583	0.002 0.0001	0.035 0.0014	0.025 0.0010	0.085 0.0033	0.075 0.0030	0.140 0.0055	0.125 0.0049	0.195 0.0077	0.175 0.0069	0.265 0.0104
225 8.8583	250 9.8425	0.002 0.0001	0.040 0.0016	0.030 0.0012	0.095 0.0037	0.085 0.0033	0.160 0.0063	0.145 0.0057	0.225 0.0089	0.205 0.0081	0.300 0.0118
250 9.8425	280 11.0236	0.002 0.0001	0.045 0.0018	0.035 0.0014	0.105 0.0041	0.090 0.0035	0.170 0.0067	0.155 0.0061	0.245 0.0096	0.225 0.0089	0.340 0.0134
280 11.0236	315 12.4016	0.002 0.0001	0.055 0.0022	0.040 0.0016	0.115 0.0045	0.100 0.0039	0.190 0.0075	0.175 0.0069	0.270 0.0106	0.245 0.0096	0.370 0.0146
315 12.4016	355 13.9764	0.003 0.0001	0.060 0.0024	0.045 0.0018	0.125 0.0049	0.110 0.0043	0.210 0.0083	0.195 0.0077	0.300 0.0118	0.275 0.0108	0.410 0.0161
355 13.9764	400 15.7480	0.003 0.0001	0.070 0.0028	0.055 0.0022	0.145 0.0057	0.130 0.0051	0.240 0.0094	0.225 0.0089	0.340 0.0134	0.315 0.0124	0.460 0.0181
400 15.7480	450 17.7165	0.003 0.0001	0.080 0.0031	0.060 0.0024	0.170 0.0067	0.150 0.0059	0.270 0.0106	0.250 0.0098	0.380 0.0150	0.350 0.0138	0.510 0.0201
450 17.7165	500 19.6850	0.003 0.0001	0.090 0.0035	0.070 0.0028	0.190 0.0075	0.170 0.0067	0.300 0.0118	0.280 0.0110	0.420 0.0165	0.390 0.0154	0.570 0.0224
500 19.6850	560 22.0472	0.010 0.0004	0.100 0.0039	0.080 0.0031	0.210 0.0083	0.190 0.0075	0.330 0.0130	0.310 0.0122	0.470 0.0185	0.440 0.0173	0.630 0.0248
560 22.0472	630 24.8031	0.010 0.0004	0.110 0.0043	0.090 0.0035	0.230 0.0091	0.210 0.0083	0.360 0.0142	0.340 0.0134	0.520 0.0205	0.490 0.0193	0.690 0.0272

PRELOADING

There are three basic reasons for preloading a ball bearing:

1) To define more precisely a shaft position by increasing bearing stiffness.
2) To keep the balls in contact with the race to prevent skidding and reduce noise.
3) To share a load, axial or radial, equally between two bearings.

PRELOADING METHODS

Conventional radial (HK) or angular contact (HA/HJ) ball bearings may be preloaded in an application using one of the following basic techniques:

1) Increase axial load to a predetermined torque range by using adjustable face clamping, for example a nut or screw.
2) Select a shim to create a predetermined torque value or axial deflection value under a reversing gage load.
3) Mount bearings with a preload spring, either between inner or outer rings or at one end of the assembly.
4) Use factory preloaded duplex pairs of bearings, which provide exact "built-in" preload when face-clamped in a DB, DF or DT configuration.

Where opposed single bearings are involved, two types of preload mounts are possible: DB (back-to-back) and DF (face-to-face). The type of mount is usually predicated on unit assembly considerations. DB mounts are most desirable where overturning moment loading is to be supported; DF mounts allow limited angular misalignment.

FACTORY-DUPLEXED PAIRS

Timken supplies pairs of radial bearings that have a precision-matched offset. When face-clamped together or against equal length spacers, a predetermined preload value is obtained. Duplex pairs are available in DB or DF configurations with preload values as selected for individual applications. To avoid unloading of either bearing in a two bearing DB or DF set, the minimum preload value should equal one-third of the applied axial load. The maximum preload limit should then be specified as at least one and a half times the minimum preload.

DT pairs, while not preloaded, are available matched to ensure equal sharing of axial load. DU pairs have offsets matched on both sides to allow use in any of the three configurations.

Matched sets of three or more bearings also are available.

ADVANTAGE OF EACH METHOD

DB – Provides excellent radial, axial and moment stability when there are no additional bearings on the shaft.

DF – Provides radial and axial stability and aligns readily with additional bearings mounted on the same shaft.

DT – Shares extra-high axial loads equally between two bearings. Does not provide stability unless further preloaded with additional bearings.

MARKING

Bearings of DB, DF and DT duplex sets have two axial lines forming a 30-degree included angle "V" etched across the outer rings of the pair (with the point of the "V" at the outer ring face to which the load is applied in the case of DT pairs).

HOW TO SPECIFY:

To specify preload, show preload type DB, DF, DT or DU and min./max. preload value desired.

Example: DB preload, 3.63 kg min. to 5.44 kg max. (8 lbs. min. to 12 lbs. max.)

Specify as: DB 8/12.

Add this suffix to the standard part number.

ROLLER BEARINGS

Roller bearings may be radially preloaded by application of bi-lobe or tri-lobe geometry to the outer ring, through use of specialized grinding techniques. Consult Timken for advice and applicability.

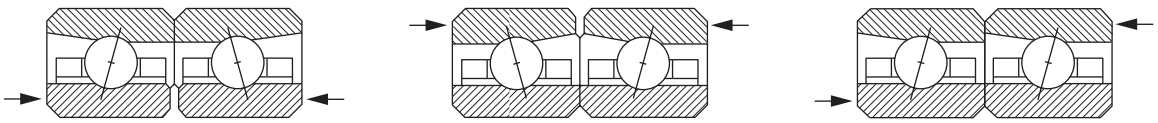


Fig. 13. Matched bearing pairs.

BEARING MOUNTING PRACTICES

Bearing fits are generally established based upon the application data such as loads, materials, temperatures and speeds. Every bearing must be properly fitted before it can meet its performance requirements. Preferably, housing and shaft tolerances should be selected in magnitudes approximately equal to the diameter tolerances of the bearing (see tolerance charts on pages 32-39). The normal fitting procedure is to press fit the ring that rotates relative to the applied radial load from bearing dimension is equal to (or matches) the shaft or housing dimension to tight. The ring stationary relative to the applied radial load is usually slip fitted from bearing dimension is equal to (or matches) the shaft or housing dimension to loose.

Heavier or out-of-balance loads may require tighter fits to avoid fretting damage to the housing or shaft. In these cases, additional radial play is required to compensate for the press fit.

Shaft and housing shoulders should be of adequate height to properly support the face of the bearing. See suggested minimum shaft and maximum housing dimensions in the bearing specification tables. Shoulders should be carefully machined to prevent misalignment and have a corner fillet radius not exceeding the radius dimension listed in the specifications.

It is always preferable to use shaft and housing materials with compatible coefficients of expansion with the bearing. Whenever this is impractical due to weight or other material consideration, use the adjacent chart to determine the possible degree of looseness or interference at temperature extremes. This additional looseness or tightness can be partially compensated for by adjusting fits and radial play.

EFFECT OF FITTING PRACTICE ON RADIAL PLAY AND PRELOAD

Keep in mind that 50 percent to 75 percent of the interference fit at any temperature extreme is reflected in loss of radial play. Press fits are even more significant in their effect on increasing preload in factory-duplexed fits. For example, with an HA 107 bearing having a 4.54 kg (10 lbs.) preload, a 0.0152 mm (0.0006 in.) press fit of the inner raceway on a solid steel shaft would increase the preload in excess of 45.36 kg (100 lbs.). To avoid excessive as-mounted preloads, pairs are either mounted with loose fits or specified as “matched and coded” on the bores and/or O.D.s so that a fit of 0.0025 mm (0.0001 in.) tight on the rotating member can be established. Contact Timken for specific application assistance.

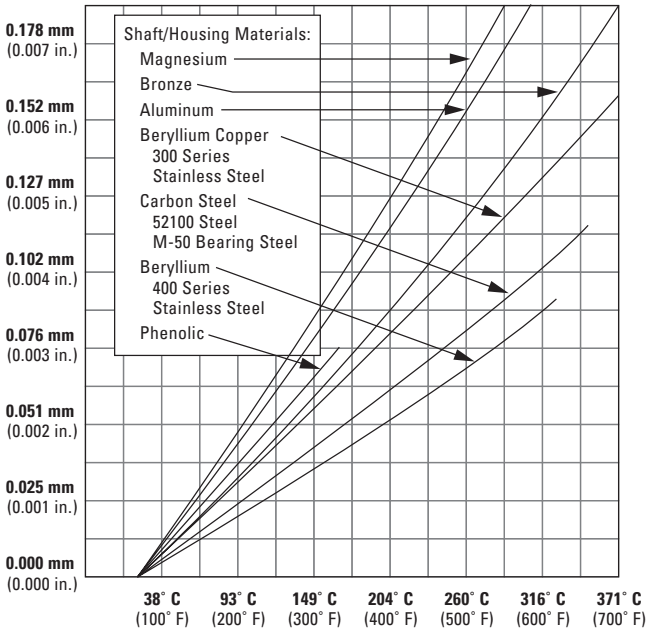


Fig. 14. Linear or diametral expansion in mm (inches) from 21° C (71° F).

To determine expansion or potential fit variation for dissimilar materials: multiply bore or O.D. diameter by the expansion for each material at the maximum temperature required. Contraction at temperatures below 21° C (71° F) is equal to the expansion for a comparable temperature differential above 21° C (71° F).

DYNAMIC LOAD RATING AND LIFE CALCULATIONS

The calculation methods in the following paragraphs yield approximate results only. In particular, they do not account for the effects of higher speeds or, for ball bearings, race curvature. More sophisticated, computer-based analyses are available by contacting Timken.

The dynamic load ratings for all ball and roller bearings described in this design guide (see bearing specification tables) are based on an average (L_{50}) life of 2500 hours or a minimum (L_{10}) life. The dynamic load rating, C_r is defined as that constant stationary radial load which a rolling element bearing could theoretically endure for a basic rating life on one million revolutions. L_{10} life for an individual rolling bearing, or a group of apparently identical rolling bearings, operating under the same conditions, is the life associated with 90 percent reliability, with contemporary, commonly used material and manufacturing quality, and under conventional operating conditions. Reference: ANSI/ABMA Std. 9 and 11.

NOTE

The load rating is a calculation device only. Under actual operating conditions, a $\frac{Cr}{P}$ ratio of less than three or more than 10 should be avoided.

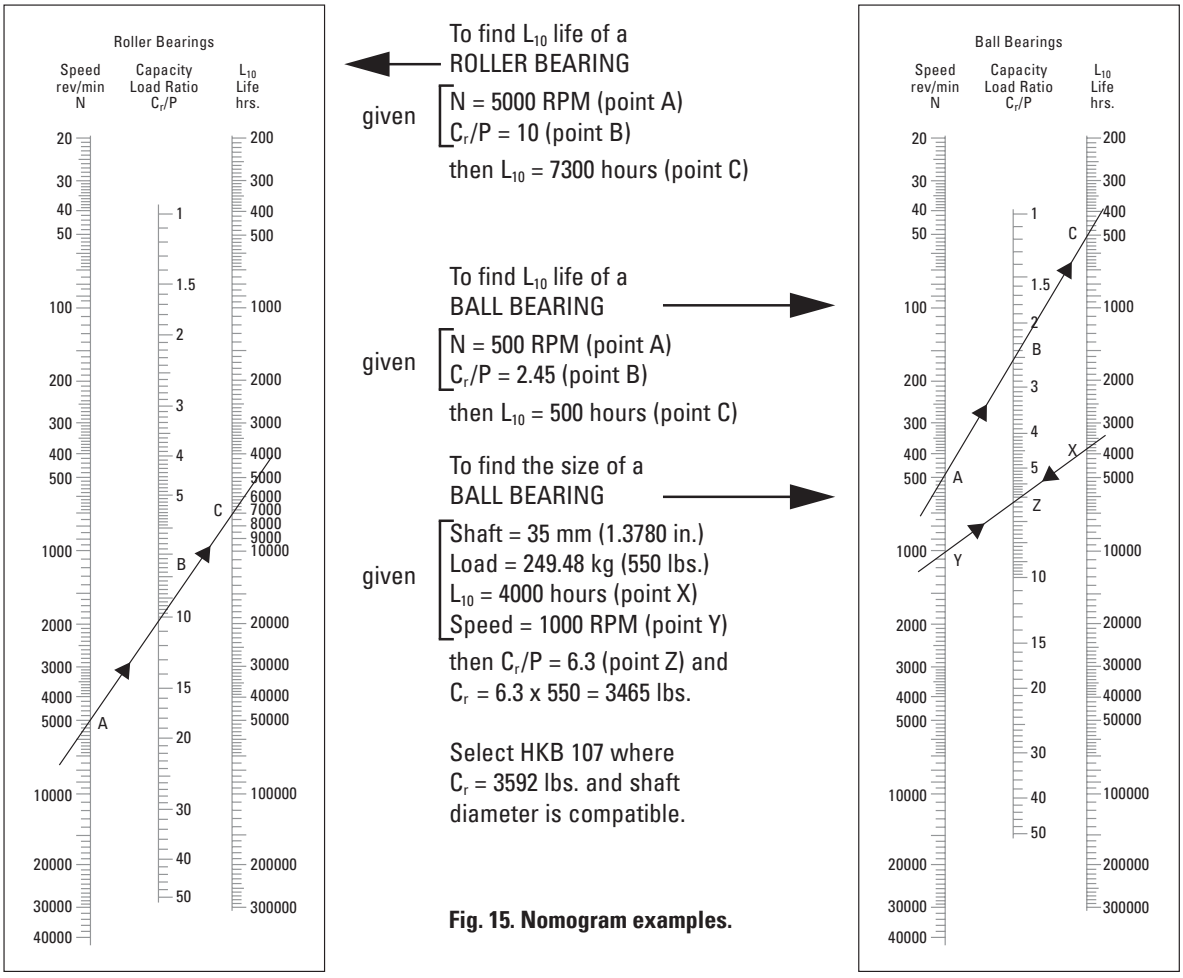
TO CALCULATE L_{10} RATING LIFE FOR OTHER LOADS AND SPEEDS:

Determine $\frac{C_r}{P}$

C_r = dynamic load rating (see bearing specification tables pages 17-21 and 26-30)

P = equivalent radial load (see page 48)

Enter the nomogram at N (the desired RPM). Draw a straight line through the $\frac{Cr}{P}$ value. The intersection point with the right hand line equals the L_{10} life.



To find L_{10} life of a ROLLER BEARING

given
- N = 5000 RPM (point A)
- C_r/P = 10 (point B)

then L_{10} = 7300 hours (point C)

To find L_{10} life of a BALL BEARING

given
- N = 500 RPM (point A)
- C_r/P = 2.45 (point B)

then L_{10} = 500 hours (point C)

To find the size of a BALL BEARING

given
- Shaft = 35 mm (1.3780 in.)
- Load = 249.48 kg (550 lbs.)
- L_{10} = 4000 hours (point X)
- Speed = 1000 RPM (point Y)

then C_r/P = 6.3 (point Z) and C_r = 6.3 x 550 = 3465 lbs.

Select HKB 107 where C_r = 3592 lbs. and shaft diameter is compatible.

Fig. 15. Nomogram examples.

TO SELECT A BEARING SIZE:

Knowing the required L_{10} life, RPM and load, the nomograms can be solved for $\frac{Cr}{P}$. Enter the nomogram at N RPM and draw a straight line to the L_{10} value. The intersection with the center line is the $\frac{Cr}{P}$ ratio. Multiply $\frac{Cr}{P}$ by P (equivalent load) and obtain C_r. Using this value, enter the C_r column in the bearing dimension and capacity tables and select a bearing with the proper capacity to suit the shaft and housing requirements.

ALTERNATE DIRECT CALCULATION METHOD

Roller Bearings

Cylindrical bearing L_{10} life

$$L_{10} = \frac{((C_r/P)^{10/3} \times 10^6)}{N \times 60}$$

Ball Bearings

Radial and angular contact bearing L_{10} life

$$L_{10} = \frac{((C_r/P)^3 \times 10^6)}{N \times 60}$$

Where:

1) L_{10} = rating life in hours
2) N = bearing speed in RPM
3) C_r = dynamic load rating (see Column C_r bearing specification table, pages 17-21 and 26-30)
4) P = equivalent radial load (see next page)

VARIABLE LOAD OR SPEED CALCULATION

Variable load and constant speed

$$P = \sqrt[x]{\frac{P_1^x f_1 + P_2^x f_2 + P_3^x f_3 + \text{---} + P_n^x f_n}{100}}$$

Variable load and variable speed

$$P = \sqrt[x]{\frac{P_1^x N_1 f_1 + P_2^x N_2 + P_3^x N_3 f_3 + \text{---} + P_n^x N_n f_n}{100\ N_m}}$$

X = 3 for ball bearings, 10/3 for cylindrical roller bearings

N_m is the mean equivalent speed where:

$$N_m = \frac{N_1 f_1 + N_2 f_2 + N_3 f_3 + \text{---} + N_n f_n}{100}$$

where: P_1, P_2, etc., equal each discrete radial load (lbs.) f_1, f_2, etc., equal percent time when each load is applied. The sum of $f_1 + f_2 + f_3 + \ldots + f_n$ must equal 100 exactly.

The resulting value P is the equivalent mean load to be used forlife calculation.

For ball bearings with combined radial and axial loads, first calculate the equivalent radial load for each condition per the preceding paragraph; then use those values to calculate the equivalent mean load.

DYNAMIC LOAD RATING AND LIFE CALCULATIONS continued

Example: A roller bearing has a variable load of 22.68 kg (50 lbs.) for 2 minutes, 11.34 kg (25 lbs.) for 3 minutes and 45.36 kg (100 lbs.) for 5 minutes.

The equivalent load with speed constant is:

$$P = \sqrt[10/3]{\frac{50^{10/3}(20) + 25^{10/3}(30) + 100^{10/3}(50)}{100}} \approx 82 \text{ lbs.}$$

In the given example, if speed also varies with load,

2000 RPM, 5000 RPM and 3000 RPM respectively, then:

$$N_m = \frac{2000\,(200) + 5000\,(30) + 3000\,(50)}{100} = 3400 \text{ RPM}$$

$$\text{lbs. } P = \sqrt[10/3]{\frac{50^{10/3}(2000)(20) + 25^{10/3}(5000)(30) + 100^{10/3}(3000)(50)}{100\,(3400)}} \approx 79$$

EQUIVALENT RADIAL LOAD (P)

In both rating life formulas below, the equivalent radial load (P) is the constant stationary radial load, which, if applied to a bearing with a rotating inner ring and stationary outer ring, would give the same life as the bearing would attain under actual conditions of load and rotation.

Roller Bearings
(cylindrical)
P= Fr

Ball Bearings:
P=Fr (radial loads)
P=XFr + YFa
(radial and axial combined loads)

Check both formulas.
Use the larger value of P
as the equivalent radial load.

where:

1) F_r = calculated radial load
2) F_a = calculated axial load
3) X = 0.50 radial factor
4) Y = axial factor

} for ball bearings under combined loads

Y is a function of F_a/C_o (axial load divided by the radial static capacity) and the radial clearance factor, f_r.

where: $f_r = \frac{\text{average radial play in inches}}{\text{ball diameter in inches}}$

To determine the value of Y for single-row ball bearings, compute f_r and select the curve closest to this value in the chart to the right. Solve for F_a/C_o and determine Y using the selected curve.

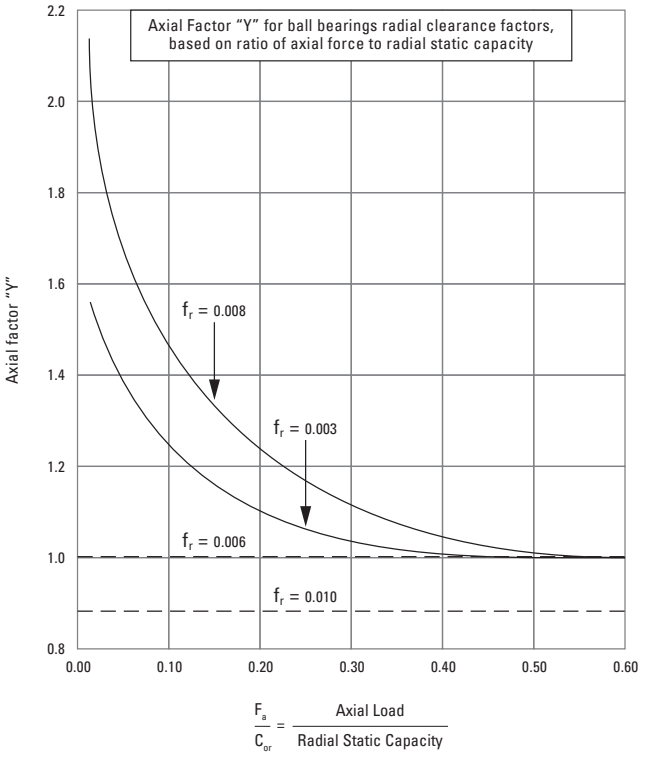


Fig. 16. Axial Factor Y

Use care to select bearings that are of sufficient size for the application. A bearing that appears to have adequate life may require a shaft so small that shaft deflection could lead to misalignment and fitting problems. A further analysis is sometimes required.

STATIC LOAD RATINGS

Ball and roller bearings loaded in a static (non-rotating) condition will experience some degree of permanent deformation at the ball-/roller-to-race contact. The static load rating is an indicator as to the magnitude of that deformation.

RATING DEFINITION

Radial static capacity, C_{0r}, is defined by ANSI/ABMA in terms of contact stress at the center of the most heavily loaded ball/roller.

- For ball bearings (except self-aligning types), the rating is based on 609KSI (4200 MPa) contact stress.
- For roller bearings, the rating is based on 580KSI (4000 MPa) contact stress.

These stresses correspond to a permanent deformation of 0.0025 mm/mm (0.0001 in./in.) of the ball or roller diameter. (Examples: a 25.4 mm [1 in.] ball or roller will have approximately 0.0025 mm [0.0001 in.] permanent deformation when loaded to C_{0r}. A 12.7 mm [0.5 in.] ball or roller will have approximately 0.0013 mm [0.00005 in.] permanent deformation). Experience has shown that most applications can tolerate this degree of permanent deformation without impairing subsequent operation.

Contact your Timken representative to discuss specific applications.

RADIALLY LOADED APPLICATIONS

For ball or cylindrical roller bearing applications subject to radial loading only, the applied load is applied directly to the C_{0r} rating.

AXIAL-LOADED OR COMBINED RADIAL-/AXIAL-LOADED APPLICATIONS

Ball Bearings

Ball bearings with combined radial and axial static loading or axial static loading only require the calculation of a static equivalent radial load, which is then applied against the C_{0r} rating. Contact your Timken representative for the applicable X_0 and Y_0 factors or see ANSI/ABMA Standard 9.

Static axial-loaded ball bearing applications may also be subject to other limitations.

- Depending on initial contact angle (radial play), groove depth and race curvature (conformity), truncation of the contact ellipse may be a limiting factor.
- Fractured-outer-ring bearings (HD series) may be limited by the ability of the holding wires to keep the fracture closed. Axial loads in excess of approximately 90.72 kg (200 lbs.), depending on bearing size, may tend to open the fracture, causing early damage. Where the housing fit can be maintained line-to-line to tight, the holding wires will no longer be the limiting factor and higher axial loads, equivalent to the HK configuration, may be applied.

Roller Bearings

Cylindrical roller bearings, depending on the ring configuration, are capable of supporting axial loads. Since the load is taken on the much larger roller end surfaces rather than on the normal contact surfaces, the C_{0r} rating does not apply; the static load is limited only by the structural strength of the ring guide flanges and their supporting shaft and housing shoulders.

LIFE ADJUSTMENT FACTORS

Life adjustment factors can be used to further define the rating life in terms of (1) reliability, (2) material and (3) application conditions. The fatigue life formula embodying these adjustment factors is:

$$L_n = a_1\ a_2\ a_3\ (L_{10})$$

a_1 = RELIABILITY FACTOR

It may be desirable for reliability factor (a_1) to determine the life when more than 90 percent of the bearings must still be operating.

Reliability L_{10} (Rating Life)	Reliability Factor (a_1)
90 percent L_{10}	1.00
95 percent L_5	0.64
96 percent L_4	0.55
97 percent L_3	0.47
98 percent L_2	0.37
99 percent L_1	0.25
99.5 percent $L_{0.5}$	0.175
99.9 percent $L_{0.1}$	0.093

Example

If the L_{10} rating life of a bearing in a specific application is 4000 hours, the L_1 life for 99 percent reliability would be
$a_1 \times L_{10} = 0.21 \times 4000 = 810$ hours.

a_2 = MATERIAL FACTOR

Certain materials have greater fatigue life than others operating under identical conditions. The theoretical L_{10} dynamic life is based on air-melt steel and standard ANSI/ABMA formulas. The life adjustment factors are based on a combination of steel type (chemistry), steel melting practice and post-melt processing of the steel. The factors are based on work done by the ANSI/ABMA and are in standards effective July 1990. This information is used in determining material life factors. There are additional life factors. Consult with a Timken sales engineer or representative for specific recommendations based on the bearing materials being considered.

a_3 = APPLICATION FACTOR

Life adjustment factors for application conditions, such as lubrication, precision, misalignment, temperature, etc., are more complex and may require more discrete analysis. For example, low viscosity oil (less than 70 ssu), high temperatures (varies with steel) and speeds insufficient to generate a hydrodynamic oil film require the use of an a_3 value of less than 1. Actual test experience in a particular application is the best way to develop accurate a_3 factors.

CONSIDERATIONS IN BEARING LIFE PREDICTION

In all discussions of the calculated dynamic load rating and L_{10} life, the factor that determines bearing life is always considered to be subsurface origin fatigue spalling of the inner or outer raceway or rolling elements. Fatigue results from cyclic stress reversals on the rolling contact surfaces and is characterized by actual loss of metal. Initially, only the vibration level of the bearing increases, but more extensive damage may follow if operation is allowed to continue. The wear rate of the cage substantially increases and the ring or one of the rolling elements may fracture, causing a total lock-up. For this reason, magnetic chip detectors are used in many critical applications to highlight early stages of fatigue in gear or bearing components.

Other modes of damage that are not statistically predictable by the conventional ANSI/ABMA formulas can affect performance. Depending on the criticality of torque and noise level, they may result in a dramatically reduced design life long before the predicted life has been achieved.

These include:

- True load brinells caused by either radial or axial impacts in excess of the static rating. Results: roughness and noise.
- False brinells caused by vibration under static conditions with inadequate lubrication. Results: fretting corrosion on raceways and shorter life.
- Wear caused by loss of lubrication or introduction of abrasive particles (contamination). Results: premature spalling of raceways and rolling elements.
- Ball/roller skidding caused by rapid acceleration with inadequate load/preload. Results: flat spots, noisy bearings, overheating and early failures.
- Ring or ball fracture or cage fracture caused by improper mounting techniques or extreme loads. Results: fractured bearing elements and early failures.
- Rotational interference caused by debris, lubricant oxidation, loss of radial play due to improper fitting procedures, corrosion, etc. Results: early failures and overheating.

LUBRICATION

Selection of the lubricant type and the method of distribution are critical to achieve successful life. Lubrication has four basic purposes:

1) Minimize rolling resistance due to deformation of the rolling elements and raceway under load by separating the mating surfaces.
2) Minimize sliding friction occurring between rolling elements, raceways and cage.
3) Transfer heat (with oil lubrication).
4) Protect from corrosion and, with grease lubrication, from contaminant ingress.

The relative importance of each depends upon the application, particularly on the speed and load. Effect of speed on different bearings can be related by the dN value (bore diameter mm x RPM).

HIGH-SPEED APPLICATIONS (OVER 1 MILLION dN)

Lubrication of high-speed (more than 1 million dN) applications is most critical. Centrifugal force tends to throw lubricant from the heavily stressed inner raceway into the outer race. Lubricant accumulation creates additional drag and heat, causing slippage or wear on the inner raceway. In high-speed applications, the most effective means of lubrication uses one or more high-velocity jets of oil directed at the inner raceway contact area with adequate escape for used lubrication around the outer race shoulders. In some applications, this can be achieved by bringing oil through holes at critical locations in the inner race. If loads are not severe, air can be mixed with oil in a non-recirculating oil mist system. With mist lubrication, air provides the cooling and cleaning functions.

MEDIUM-SPEED APPLICATIONS (10000 TO 1 MILLION dN)

In the broad range of 10000 to 1 million dN, which encompasses most bearing applications, the lubricant's cooling function is less critical. A circulating or replenishment oil system is still preferable for optimum life, but a controlled quantity of grease may be used if temperatures are low. With above ambient temperatures, grease frequently deteriorates long before the predicted fatigue life of the bearing. Unless the bearings are periodically regreased with the proper amount of lubricant, early fatigue may result. New developments in high-temperature greases provide a partial solution to the problem.

Bearing fatigue life can be prolonged beyond that predicted in this design guide if full fluid film elastohydrodynamic lubrication is established at the contact surface. To achieve this, the fluid film thickness must be equal to or greater than contact surface finish or microgeometry variations at the most heavily loaded

LUBRICATION continued

contact area. Without full fluid separation, metal contact occurs, causing higher surface shear stress, possible wear and reduced life.

Fluid film separation is influenced by: 1) size, design and precision of the bearing; 2) speed; 3) applied load; and 4) viscosity characteristics of the oil at operating temperatures.

Most medium-speed bearings operating with high-quality mineral oils under average loads establish full fluid film separation. However, where low viscosity fluids or lubricants are required, fluid film may not be established, resulting in reduced life (e.g., hydraulic pumps and fuel control systems). Bearings operating in jet fuel yield less than 10 percent of normal life. Timken Aerospace computer programs utilizing the above variables are available to assist designers in determining adequacy of the lubricant. Then, design or application modifications can be reviewed to compensate for or accept potential life reductions.

Where fluid film cannot be maintained due to low speeds and high bearing loads, grease lubrication may prove advantageous. Extreme pressure additives in some greases provide good boundary lubrication and lubricity even though the viscosity characteristics of the oil provide marginal fluid film support.

The selection of oil viscosity for any bearing application requires consideration of several factors: load, speed, bearing setting, type of oil, and environmental factors. Since viscosity varies inversely with temperature, a viscosity value must always be stated with the temperature at which it was determined. High viscosity oil is used for low-speed or high-ambient temperature applications. Low viscosity oil is used for high-speed or low-ambient temperature applications.

The measure of viscosity uses multiple units that depend upon the test method used in the evaluation. There are several viscosity terms, such as absolute, kinematic and apparent. The units used in most modern analysis programs are the kinematic viscosity expressed in centistokes (cs). It can be related to the absolute viscosity, expressed in centipoise (cp) by the oil density. The purpose of the lubrication, ideally, is to separate the moving elements in a bearing by developing a protective film, thereby avoiding metal-to-metal contact at the surface finish asperities.

Lubricants are temperature limited. Mineral oils may be utilized at temperatures not exceeding -40° C to 107° C (-40° F to 225° F).

Synthetic esters and di-esters may be utilized at temperatures not exceeding -54° C to 176° C (-65° F to 350° F).

Degradation of the lubrication film is most affected by oxidation and is accelerated at higher temperatures.

LUBRICATION FILTRATION

To obtain the greatest benefit from the lubrication supplied, it is important that the lubrication system is properly filtered. For oil lubrication in critical applications where speeds are moderate to high, use of a 3 to 5 micron filter is advised. Be aware that a hard particle greater than 2.5 to 7.5 microns (0.0001 to 0.0003 inches) can cause wear, scuffing and other surface distress. When grease is used, it also should be filtered prior to installation, since unfiltered grease may be highly contaminated. Filtering the grease with a 5 micron filter is recommended.

LOW-SPEED APPLICATIONS

Under slow speed or oscillating conditions, bearings no longer depend on fluid film separation, but operate with metal-to-metal contact. Wear is minimized by grease lubricants with high lubricity and extreme pressure additives providing effective “boundary layer” separation. Thin, dry-film coatings may be added to further improve wear resistance.

Standard lubrication

Most aircraft turbine and transmission bearings operate with supplemental replenishment lubricant systems. Therefore, unless otherwise specified, all open bearings with cages are supplied with a preservative coating meeting MIL-PRF-32033. Open bearings with nonmetallic cages are supplied with

a light oil preservative per MIL-PRF-6085. These are non-operating coatings rather than lubricants. They are, however, compatible with most lubricants and generally do not need to be removed prior to mounting.

Sealed bearings are normally lubricated with a controlled quantity of sodium soap grease. This provides excellent channeling characteristics, resulting in minimum torque and heat generation.

Special lubricants

Timken maintains an inventory of oils and greases for use in special applications exposed to extreme conditions of temperature, vacuum, moisture or radiation. Where initial lubrication must last the life of the bearing, grease is preferable to oil (except for instrument-type applications having sensitive torque requirements). The choice of grease is a function of oil and thickener type as well as the additive package to meet many special requirements.

HOW TO SPECIFY

The greases listed with the Timken lubricant code are typical of those frequently specified. The lubricant code should be identified when ordering the bearing. For a more complete list, consult your Timken representative.

Timken Lubrication Code	Brand Name	Manufacturers' Suggested Temp.Range	Comments
LY 263	Aeroshell 22	-65 to +204° C -85 to +400° F	Non-melting, inorganic thickener with synthetic hydrocarbon oil for excellent fatigue life over wide temperature ranges. General-purpose lubricant, meets MIL-PRF-81322.
LY 708	Mobil 28	-65 to +177° C -85 to +350° F	Organic bentonite clay binder with synthetic hydrocarbon oil. Has EP additives. Meets MIL-PRF-81322.
LY 240	Shell Darina E P 2	-30 to +175° C -20 to +350° F	Similar to LY 270 except uses non-melting, inorganic thickener to enhance high-temperature operation.
LY 270	Shell Alvania E P 2	-30 to +149° C -20 to +300° F	Lithium soap, mineral oil, extreme pressure lubricant. Excellent water resistance for long design life under adverse operating conditions.
LG 38	Exxon Andok B	-30 to +110° C -20 to +225° F	Long design life, sodium soap, mineral oil grease with excellent channeling characteristics for low torque after run in at all speeds. Limited operating temperature range.
LY 189	Dupont Krytox 240 AC	-25 to +315° C -10 to +600° F	Teflon®-type thickener with fluorocarbon oil for maximum high-end temperatures. Chemically inert and insoluable in all fuels and most solvents. Premium price. Meets MIL-PRF-27617.

Table 9. Timken lubrication codes.

ULTRA-HIGH-SPEED PERFORMANCE FEATURES

To operate successfully above 2 million dN speeds, specifically engineered designs have been developed through close cooperation between Timken and the bearing user. Lubrication flow pattern is one of the most important factors. Timken has the manufacturing technology to fabricate both ball and roller bearings in VIM-VAR M-50 steel with integral inner raceway lubrication. Two-piece inner ring mainshaft bearings with lubricant directed between the halves, and mainshaft roller bearings with lubrication holes in precision undercuts (adjacent to guide flanges and to the cage pilot surface) efficiently provide lubricant to critical locations. Both wear and fatigue life are improved while less oil is needed, resulting in higher efficiency and less heat generation.

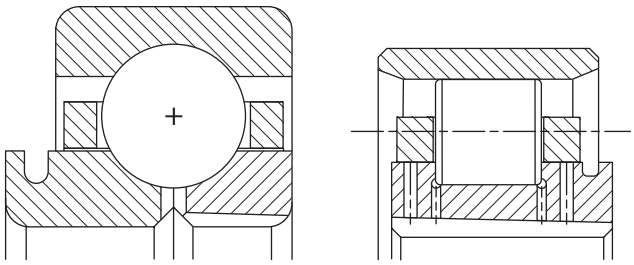


Fig. 17. Ultra-high-speed performance feature examples.

Where the application warrants:

1) Ultraprecise rollers can be manufactured by Timken with end squareness as low as 0.0013 mm (0.00005 in.) and corner radius runout as low as 0.0127 mm (0.0005 in.).
2) Slight roller end crown, low guide flange angles and reduced clearances can be combined to further improve roller tracking and permit even higher speeds.
3) Special roller crowns can be used to allow for greater misalignment.
4) The one-piece broached cage can be modified with relieved areas to improve lubrication and reduce wear.

The extensive use of VIM-VAR M-50 steel in many turbine and accessory positions testifies to its value as the preferred material for ultra-high-speed bearings.

In all cases where special designs are required, consult your Timken representative for assistance in selecting the necessary features.

VISCOSITY CONVERSION TABLE

SUS Saybolt	R" Redwood	E Engler	cSt Centistokes
sec.	sec.	deg.	mm²/s
35	32.2	1.18	2.7
40	36.2	1.32	4.3
45	40.6	1.46	5.9
50	44.9	1.60	7.4
55	49.1	1.75	8.9
60	53.5	1.88	10.4
65	57.9	2.02	11.8
70	62.3	2.15	13.1
75	67.6	2.31	14.5
80	71.0	2.42	15.8
85	75.1	2.55	17.0
90	79.6	2.68	18.2
95	84.2	2.81	19.4
100	88.4	2.95	20.6
110	97.1	3.21	23.0
120	105.9	3.49	25.0
130	114.8	3.77	27.5
140	123.6	4.04	29.8
150	132.4	4.32	32.1
160	141.1	4.59	34.3
170	150.0	4.88	36.5
180	158.8	5.15	38.8
190	167.5	5.44	41.0
200	176.4	5.72	43.2
220	194.0	6.28	47.5
240	212	6.85	51.9
260	229	7.38	56.5
280	247	7.95	60.5
300	265	8.51	64.9
325	287	9.24	70.3
350	309	9.95	75.8
375	331	10.7	81.2
400	353	11.4	86.8
425	375	12.1	92.0

SUS Saybolt	R" Redwood	E Engler	cSt Centistokes
sec.	sec.	deg.	mm²/s
450	397	12.8	97.4
475	419	13.5	103
500	441	14.2	108
550	485	15.6	119
600	529	17.0	130
650	573	18.5	141
700	617	19.9	152
750	661	21.3	163
800	705	22.7	173
850	749	24.2	184
900	793	25.6	195
950	837	27.0	206
1000	882	28.4	217
1200	1058	34.1	260
1400	1234	39.8	302
1600	1411	45.5	347
1800	1587	51	390
2000	1763	57	433
2500	2204	71	542
3000	2646	85	650
3500	3087	99	758
4000	3526	114	867
4500	3967	128	974
5000	4408	142	1082
5500	4849	156	1150
6000	5290	170	1300
6500	5730	185	1400
7000	6171	199	1510
7500	6612	213	1630
8000	7053	227	1740
8500	7494	242	1850
9000	7934	256	1960
9500	8375	270	2070
10000	8816	284	2200

To convert from	to	Multiply by	
Acceleration			
foot/second^2	meter/second^2	m/s^2	0.3048
inch/second^2	meter/second^2	m/s^2	0.0254
Area			
foot^2	meter^2	m^2	0.09290304
inch^2	meter^2	m^2	0.00064516
inch^2	millimeter^2	mm^2	645.16
yard^2	meter^2	m^2	0.836127
mile^2 (U.S. statute)	meter^2	m^2	2589988
Bending Moment or Torque			
dyne-centimeter	newton-meter	N-m	0.0000001
kilogram-force-meter	newton-meter	N-m	9.806650
pound-force-inch	newton-meter	N-m	0.1129848
pound-force-foot	newton-meter	N-m	1.355818
Energy			
BTU (International Table)	joule	J	1055.056
foot-pound-force	joule	J	1.355818
kilowatt-hour	megajoule	MJ	3.6
Force			
kilogram-force	newton	N	9.806650
kilopound-force	newton	N	9.806650
pound-force (lbf avoirdupois)	newton	N	4.448222
Length			
fathom	meter	m	1.8288
foot	meter	m	0.3048
inch	millimeter	mm	25.4
microinch	micrometer	µm	0.0254
micron (µm)	millimeter	mm	0.0010
mile (U.S. statute)	meter	m	1609.344
yard	meter	m	0.9144
nautical mile (UK)	meter	m	1853.18
Mass			
kilogram-force-second^2/meter			
(mass)	kilogram	kg	9.806650
kilogram-mass	kilogram	kg	1.0
pound-mass (lbm avoirdupois)	kilogram	kg	0.4535924
ton (long, 2240 lbm)	kilogram	kg	1016.047
ton (short, 2000 lbm)	kilogram	kg	907.1847
tonn	kilogram	kg	1000.000

To convert from	to	Multiply by	
Power			
BTU (International Table)/hour	watt	W	0.293071
BTU (International Table)/minute	watt	W	17.58427
horsepower (550 ft lbf/s)	kilowatt	kW	0.745700
BTU (thermochemical)/minute	watt	W	17.57250
Pressure or Stress (Force/Area)			
newton/meter^2	pascal	Pa	1 .0000
kilogram-force/centimeter^2	pascal	Pa	98066.50
kilogram-force/meter^2	pascal	Pa	9.806650
kilogram-force/millimeter^2	pascal	Pa	9806650
pound-force/foot^2	pascal	Pa	47.88026
pound-force/inch^2 (psi)	megapascal	MPa	0.006894757
Temperature			
degree Celsius	kelvin	k	$t_k = t_c + 273.15$
degree Fahrenheit	kelvin	k	$k = \frac{5}{9} (t_f + 459.67)$
degree Fahrenheit	Celsius	°C	$t_c = \frac{5}{9} (t_f - 32)$
Velocity			
foot/minute	meter/second	m/s	0.00508
foot/second	meter/second	m/s	0.3048
inch/second	meter/second	m/s	0.0254
kilometer/hour	meter/second	m/s	0.27778
mile/hour (U.S. statute)	meter/second	m/s	0.44704
mile/hour (U.S. statute)	kilometer/hour	km/h	1.609344
Volume			
foot^3	meter^3	m^3	0.02831685
gallon (U.S. liquid)	liter	l	3.785412
liter	meter^3	m^3	0.001
inch^3	meter^3	m^3	0.00001638706
inch^3	centimeter^3	cm^3	16.38706
inch^3	millimeter^3	mm^3	16387.06
ounce (U.S. fluid)	centimeter^3	cm^3	29.57353
yard^3	meter^3	m^3	0.7645549

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